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

NOV - 1 2016

Refer To NMFS No.: WCR-2016-5574

Ms. Kendall Schinke
Chief
Department of Transportation, District 3
Office of Environmental Management
2379 Gateway Oaks Drive (MS-19)
Sacramento, California 95833

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations for the CalTrans Bridge Retrofit Project (03-SAC-05 and 160, EA 03-3F090)

Dear Ms. Schinke:

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 Seismic Retrofit Project (project) on four bridges at three different locations located in Sacramento 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 March 10, 2016. On September 14, 2016, formal consultation was initiated by NMFS' California Central Valley Office (CCVO).

This BO is based on the biological assessment provided on March 10, 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 well as 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 contact Neal McIntosh at (916) 930-3721, or via e-mail at neal.mcintosh@noaa.gov, if you have any questions regarding this response or require additional information.

Sincerely,

for Barry A. Thom
Regional Administrator

Enclosure: Biological Opinion

cc: California Central Valley Office Division- File Copy
ARN 151422-WCR2016-SA00279

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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Magnuson-Stevens Fishery Conservation and Management Act (MSA) Essential Fish Habitat (EFH) Consultation, and Fish and Wildlife Coordination Act (FWCA) Recommendations

Bridge Seismic Retrofit Project 03-3F090
Mokelumne River Bridges I-5 in Sacramento County,
Paintersville Bridge SR-160 in Sacramento County, and
North Sacramento Undercrossing SR-160 in the City of Sacramento

National Marine Fisheries Service Consultation Number: WCR-2016-5574

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?
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit (ESU)	Endangered	No	Yes	No	No
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU	Threatened	No	No	No	No
California Central Valley steelhead (*Oncorhynchus mykiss*) distinct population segment (DPS)	Threatened	Yes	No	No	No
Southern DPS of North American green sturgeon (*Acipenser medirostris*)	Threatened	Yes	Yes	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: Maria Rea

for Barry A. Thom
Regional Administrator

Date: NOV - 1 2016

List of Acronyms and Abbreviations

2010 CSS – 2010 Caltrans Standard Specifications
ACID – Anderson-Cottonwood Irrigation Dam
BA – biological assessment
BMP – best management practice
BO – biological opinion
Caltrans – California Department of Transportation
CCV – California Central Valley
CCVO – California Central Valley Office
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulations
cfs – cubic feet per second
CV – Central Valley
CVP – Central Valley Project
CVRWQCB – Central Valley Regional Water Quality Control Board
Delta – Sacramento-San Joaquin Delta
DO – dissolved oxygen
DPS – distinct population segment
DQA – Data Quality Act
EBMUD - East Bay Municipal Utility District
EFH – essential fish habitat
EPA – Environmental Protection Agency
ESA – Endangered Species Act
ESU – evolutionarily significant unit
FHWG – Fisheries Hydroacoustic Working Group
FMP – Fisheries Management Plan
FR – Federal Register
FWCA – Fish and Wildlife Coordination Act
GCID – Glenn-Colusa Irrigation District
HAPCs – habitat areas of particular concern
ITS – incidental take statement
LWM – large woody material
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NB - northbound
NMFS – National Marine Fisheries Service
NTU – nephelometric turbidity unit
OHWM – ordinary high water mark
PAHs – polycyclic aromatic hydrocarbons
PBF – physical or biological feature
PCBs – polychlorinated biphenyls
PCE – primary constituent element
ppt – parts per thousand
PVA – population viability analysis
Reclamation – U.S. Bureau of Reclamation
RM – river mile

RMS – root mean square
SB - southbound
sDPS – southern distinct population segment
SEL – sound exposure level
SR – state route
SWE – snow water equivalent
SWP – State Water Project
SWRCB – State Water Resource Control Board
TCP – temperature compliance point
USC – United States Code
USFWS – U.S. Fish and Wildlife Service
USGS – United States Geological Survey
VSP – viable salmonid population
WPCP – Water Pollution Control Program
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 USC 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 USC 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 Area Office.

1.2 Consultation History

- On March 10, 2016, the NMFS West Coast Region – California Central Valley Office (CCVO) received a consultation initiation request and Biological Assessment (BA) from Caltrans for the Bridge Seismic Retrofit Project for the Mokelumne River I-5 Bridges in Sacramento County, the Paintersville Bridge over the Sacramento River on State Route (SR) 160 in Sacramento County, and the North Sacramento Undercrossing on SR-160 in the City of Sacramento. Listed species and critical habitats in the action areas include Sacramento River winter-run Chinook salmon ESU and their critical habitat, Central Valley (CV) spring-run Chinook salmon ESU and their critical habitat, California Central Valley (CCV) steelhead DPS and their critical habitat, and southern DPS (sDPS) of North American green sturgeon and their critical habitat.
- On August 22, 2016, NMFS received additional project details from Caltrans.
- On September 14, 2016, NMFS initiated formal consultation.
- On October 6, 2016, Caltrans, USFWS, and NMFS came to an agreement on a four month in-water work window for the Paintersville Bridge site.

1.3 Proposed Action

This section summarizes the proposed action. The term "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). "Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). There are no interrelated or interdependent actions associated with the Project.

The proposed project involves retrofitting multiple bridges to be more robust to potential damage from seismic events. The bridges are the Mokelumne River Bridges (Bridge No. 29-0197L/R) at Interstate 5, northbound (NB) and southbound (SB), at the San Joaquin and Sacramento Counties border line; the Paintersville Bridge over the Sacramento River (Bridge No. 24-0053) at State Route (SR) 160 in Sacramento County; and the North Sacramento Undercrossing (Bridge No. 24-011L) at SR 160 SB in the City of Sacramento. There are no aquatic habitats present in the North Sacramento Undercrossing proposed action area, so that site will not be considered further in this BO. According to the BA provided by Caltrans (Caltrans 2016), inspections revealed that the Mokelumne River Bridges are in need of retrofit due to short seat hinges with frames of different stiffness and short pier columns. The Paintersville Bridge is in need of retrofit due to vulnerable bearing and supports at both the abutments and the piers, and pier and abutment footings which may not withstand "moments" due to earthquakes, and due to weakened steel truss members (Caltrans 2016). The work intends to ensure that the structures will perform adequately in a seismic event.

1.3.1 Mokelumne River Bridges

The proposed action consists of a number of seismic retrofit activities at the Mokelumne Bridge. The total working days estimate for all types of project activities is 340 working days. The work will be accomplished over two construction seasons, with 170 working days estimated per season. In-water activities in Mokelumne River will be accomplished in a single construction season with 60 in-water working days estimated within the work window of July 15th to October 15th.

1.3.1.1 Substructure retrofit – bent cap extension retrofit

The existing bridge piers at the Mokelumne River Bridges are multi-column bents of five columns each. A bent is a type of pier comprised of multiple columns that usually support beams and girders of the bridge superstructure. The vertical members of a bent are columns, and the horizontal member of a bent is the bent cap. Each of the two Mokelumne River Bridges is supported by 20 bents, for 40 bents total for the two bridges. The proposed project will replace each of the current, five column bents with outrigger bents of two columns each. The new bent columns will be 48-inch diameter cast-in-steel-shell (CISS) piles. The CISS piles are open-ended cylindrical concrete piers within a steel shell. The piles are installed by pile driving, after which they are dewatered and filled with concrete and steel. Caltrans expects that a hammer similar to the APE D100-42 may be used to drive the CISS piles. The proposed project will include a bent cap that will connect the two CISS piers. Outrigger bents have bent caps that extend out beyond the edges of the bridge deck and columns that are offset from the bridge deck. The bent caps receive the load from the superstructure and transfer it to the piles. Outrigger bents are a popular retrofit in potentially liquefiable soil or when overall stability is a problem. Following the construction of the new outrigger bents, the existing bents will be removed.

Of the 20 bents on each bridge, two on each bridge (bents 4 and 5) are located near or below the ordinary high water mark (OHWM) of the Mokelumne River (Figure 1). This equates to 20 existing columns near or below the OHWM, which will be replaced by eight columns following the retrofit. To access bents 4 and 5, a temporary rock causeway of clean gravel and/or cobble will likely be employed.

Pile driving equipment will likely access the proposed action area along the existing levee access road and be employed from a tracked crane or tracked long-boomed vehicle. The construction of the outrigger bents will require the construction of temporary falsework.

Figure 1. Mokelumne River Bridges eastern and western spans. Bents shown are bents 4 and 5 which are near or below the ordinary high water mark (from Caltrans 2016).

1.3.1.2 Substructure retrofit – abutment retrofit

The proposed project will strengthen the existing abutments on the Mokelumne River Bridges. The abutment footings will be enlarged and new piles will be constructed. Each abutment will be strengthened by two 48-inch diameter CISS piles which will be added on either side of each of the existing abutments and a pile cap to evenly displace the load between the two piles. The new pile caps will be similar in structure and function as the proposed outrigger bent caps. The pile caps will be attached to the existing abutment diaphragm using a “dowel drill and bond” technique which will effectively serve to widen the existing abutment pile cap.

The construction methods used for the abutment retrofit will be similar to those used for the bent cap extension retrofit. Caltrans expects that a hammer similar to the Delmag D36-32 or APE D100-42 may be used to drive the CISS piles.

1.3.1.3 Superstructure retrofit – pipe seat extenders and hinge restrainers

The in-span hinges between bridge segments will be modified to be more robust to seismic events by the proposed project. The proposed action at the Mokelumne River Bridges will add pipe seat extender and hinge restrainers to the hinges of each of the bridges. Pipe seat extenders are pipes used to extend the seat hinge, and they are designed to be strong enough to support the superstructure if unseating of the hinge occurs. Pipe seat extenders are attached to one side of the joint and move freely over the over side. Hinge restrainers are steel cables or rods that hold the bridge frames together at the hinges in the event of an earthquake.

The installation of hinge restrainers and pipe seat extenders requires access to the interior of the bridge frames. Holes will be cored through the hinge diaphragms to gain access to the interior of the bridge frames. Hinge restraining cables will be anchored by placing a swaged fit threaded rod to bear a nut against a thick bearing plate that accommodates the whole cable group. A shim will be placed between the nuts and the bearing plate to allow for thermal movements. The cables are tightened snugly. It may be possible to feed the restrainer cables through the hollow space within the pipe extenders.

Pipe extenders are typically 8-inch in diameter. Pipe extenders are fixed at one end of the hinge and free to slide at the other end. The pipes are run through cored holes in the hinge diaphragms. The fixed end of the pipe is usually on the bearing side of the hinge. A steel bolster is placed on the non-anchored side of the hinge. The pipe typically extends 6 to 12-inches beyond the edge of the bolster face. A plate may be welded to the end of the pipe to limit the ultimate gap expansion.

1.3.2 Paintersville Bridge

The proposed action consists of a number of seismic retrofit activities at the Paintersville Bridge over the Sacramento River. The total working days estimate for all types of project activities is 200 working days. The work will be accomplished over two construction seasons, with 100 working days estimated per season. In-water activities in the Sacramento River at four piers will be accomplished over two construction seasons with 80 in-water working days estimated per season within the work window of July 1st to October 31st.

1.3.2.1 Substructure retrofit – abutment retrofit

The proposed project will strengthen the existing abutments on the Paintersville Bridge. The abutment footings will be extended and strengthened by installing a pair of 24-inch diameter CISS on each side of the existing abutments. Each pile pair will be topped with a 5-foot deep, 8-foot long, and 4-foot wide reinforced concrete pile cap to evenly displace the load between the two piles. A reinforced concrete cross beam will also be added to the existing abutment diaphragm between the abutment seats. The new pile caps and the new cross beam will be attached to the existing abutment diaphragm using a "dowel drill and bond" technique which will effectively serve to widen the existing abutment pile cap.

The piles will be installed by impact pile driving, after which they are dewatered and filled with concrete and steel. Caltrans expects that a hammer similar to the Delmag D36-32 or APE D100-42 may be used to drive the CISS piles. Pile driving equipment will likely access the proposed action area along the existing levee access road and be employed from a tracked crane or tracked long-boomed vehicle. The construction of the new concrete pile cap abutment extension will require soil excavation, the construction of temporary wooden forms, and concrete pouring.

1.3.2.2 Substructure retrofit – pier retrofit

The existing piers on the Paintersville Bridge are supported by a pile footing and pile cap. Beneath the water, rows of piles bear the load of the structure, while above water it appears as though the pier is a single support. To provide greater stability, the proposed action will construct a reinforced concrete collar at each pier. The new pier collars will each be supported by two 96-inch diameter CISS piles. Four piers will be retrofit for a total of eight new 96-inch diameter piles. The new piles and pier collar will resemble a new bent with the bent cap forming a collar around the existing pier. The pier collar will be constructed above the high water mark of the Sacramento River. The collars will be tied to the existing piers using drill and bond dowels. The Steamboat Slough Bridge approximately one mile south of the Paintersville Bridge recently had a similar pier retrofit.

The pier retrofit will require the construction of a temporary trestle from each side of the Sacramento River levee in order to access the existing Paintersville Bridge piers. The temporary trestles are expected to be constructed on bents supported by temporary 18-inch to 20-inch diameter steel pipe piles capped or braced by steel beams. It is expected that each bent will be composed of five piles and each bent will be spaced 30 to 35 feet apart. Construction of the temporary trestles is expected to require the installation of about 240 18-inch to 20-inch diameter steel pile piles, assuming approximately 120 piles per trestle. Caltrans expects to build a trestle from one side of the levee during one working season, dismantle it, and then build from the opposite bank during the following season.

Both the proposed permanent CISS piles and the temporary steel piles will be installed via impact pile-driving. The temporary steel piles are expected to be driven to a depth of 60 feet below the mud line. Caltrans expects that a hammer similar to the Delmag D36-32 or APE D100-42 may be used to drive the temporary steel piles. Caltrans expects that a hammer similar to the APE D180-42 may be used to drive the CISS piles. The temporary trestles will be completely disassembled and removed following the completion of the pier retrofit. The temporary steel piles will likely be removed using a vibratory extractor. Pile driving equipment will likely access the proposed action area along the existing levee access roads and levee bank to access the temporary trestles. Pile driving will be employed from a tracked crane or tracked long-boomed vehicle. The construction of the pier collars will require the construction of temporary falsework and concrete pouring.

1.3.2.3 Superstructure retrofit – steel truss strengthening

The existing steel trusses and truss connections will be strengthened via the proposed action by the addition of gusset plates. Gusset plates are thick sheets of steel used for joining structural components. Gusset plates will be installed at the intersection of two or more beams, chords, or columns and fastened with bolts or by welding. In addition to joining components together, gusset plates add strength and support to each joint.

Installation of gusset plates will be performed from the existing bridge deck using small equipment such as a man-lift or a boom truck.

1.3.2.4 Replace dolphins

Paintersville Bridge currently has eight dolphins each composed of seven creosote-treated timber piles. Dolphins are free-standing aquatic structures that extend above the water level. Dolphins are typically used to display regulatory information, serve as navigational aids, or to cushion ship impacts, much like a fender. Typically dolphins are composed of a number of piles driven into the riverbed that are connected above the water level to provide a platform or fixing point. The proposed action will replace the existing dolphins with similar dolphins composed of treated timber, plastic, or steel piles.

Dolphin replacement will be accomplished via pile driving using the temporary work trestle as a construction platform. The piles of the existing dolphins will be removed by cutting them below the mudline or by vibratory extraction. Replacement timber, steel, or plastic piles will be driven into the riverbed with an impact hammer. Caltrans expects that a hammer similar to the Delmag D36-32 or APE D100-42 may be used to drive the piles for the new dolphins.

Figure 2. Existing dolphins at Paintersville Bridge (from Caltrans 2016).

1.4 Avoidance and Minimization Measures

1.4.1 Mokelumne River Bridges

Pile driving and sound attenuation

Caltrans will use a NMFS-approved aquatic sound attenuation device to reduce the transmission of sound through water during pile driving activities. Sound attenuation devices that may be approved by NMFS include: 1) un-confined air bubble curtain, or 2) de-watered attenuation casing or confined air bubble curtain.

The Caltrans project engineer will be required to inspect the sound attenuation system for proper functionality and operation prior to each deployment and during deployment. Proper operation during deployment will be determined by the gauges on the monitoring system and by any other methods determined by the engineer. Air pressure and air flow meters will be calibrated by a private laboratory approved by the Caltrans engineer, prior to use in the air bubble curtain system. The condition of the sound attenuation system will be monitored, and daily inspection reports will be generated during pile driving activities and no less than every other day during periods of no activity.

The approved sound attenuation system must be operating prior to beginning pile driving at any given pile location. If the attenuation system fails, pile driving will cease immediately and may not resume until the Caltrans engineer has inspected the attenuation system and confirmed that it is fully functional and fully operational. A sound attenuation system will not be required for pile driving or casing installation activities using a vibratory hammer method. Pile driving equipment shall be isolated from the platform it is on. Isolation shall be such that noise from the pile driving operation is not transmitted through the platform into the water, generating excess noise. The platform supporting the pile driving equipment is not required to be contained within the attenuation system.

Construction planning and methods

Effects to listed species and critical habitat will be avoided and/or minimized by designating environmentally sensitive areas within the action area. Avoidance of these areas will be incorporated into all phases of construction, and information about these areas will be readily available and presented to all personnel involved with construction. For the purposes of this project, all areas outside of the action area will be considered environmentally sensitive. Establishment of environmentally sensitive areas will occur prior to construction and will remain in effect until all phases of the project are completed.

Before any work occurs in the action area, a NMFS-approved, qualified biologist will conduct an environmental awareness training to all construction personnel including contractors and sub-contractors. This training will brief them on the need to avoid and minimize effects to listed species and their designated critical habitat, as well as other sensitive biological resources, adjacent to and within the action area and penalties to applicable state and Federal permit requirements. The biologist will inform all construction personnel about the life history and habitat requirements of special status species that may occur in the action area, the importance of leaving habitat components intact and the terms and conditions stipulated by biological resource agencies as applicable (NMFS, California Department of Fish and Wildlife (CDFW), and the U.S. Fish and Wildlife Service (USFWS)). Training will cover general guidelines for minimizing and avoiding impacts to listed species and critical habitat. Best management practices (BMPs) will be identified, explained, and written into construction specifications to avoid construction-related effects, sedimentation, pollution/contamination, and damage to riparian vegetation and other critical habitat components.

Discharge of turbid water into the Mokelumne River during construction activities will be prevented by filtering the discharge with a filter bag, diverting the water to a settling tank or infiltration area, and/or treating the water in a manner to ensure that discharges conform to the water quality requirements of the waste discharge permit issued by the Central Valley Regional Water Quality Control Board (CVRWQCB) prior to entering receiving waters.

The in-water work window, defined as any work occurring below the ordinary high water mark (OHWM) within the action area, shall occur between July 15^{th} and no later than October 15^{th}. Work below the OHWM may include installation and removal of a temporary work pad, removal of existing piles, and installation of new piles. This work window will serve to minimize and/or avoid potential adverse effects to listed species and their critical habitat.

BMPs for preventing sedimentation, turbidity, and pollution

Caltrans shall implement mitigation measures to contain construction-related material in manageable locations and prevent debris from entering surface waters during in-water work and for construction operations outside of receiving waters. Compliance with all construction site BMPs specified in the approved water pollution control program (WPCP) and any other permit conditions will be mandatory to minimize discharge of construction-related sediment and/or contaminants into the Mokelumne River. In order to achieve this and reduce the potential for discharge, Caltrans shall follow all applicable guidelines and requirements outlined in the 2010 Caltrans Standard Specifications (2010 CSS) (Caltrans 2010), Section 13, regarding water pollution control and general specifications for preventing, controlling, and abating water pollution in streams, waterways, and other bodies of water. Considerations for project-specific BMPs shall include waste management practices; sediment control; and vehicle tracking control. BMPs will be based on best available science, as well as best conventional and best available technology. Caltrans staff shall perform routine inspections of the project area to verify that BMPs are properly implemented and maintained, and are operating effectively in accordance with design standards. BMPs and mitigation measures selected must meet the standards and objectives to minimize water pollution impacts set forth in the 2010 CSS.

BMPs will be implemented to prevent sedimentation and turbidity in all phases of the project. Specific measures for soil erosion will be implemented and in place prior to, during, and after construction to ensure that no silt or sediment enters the Mokelumne River. Areas where a disturbance of soil has occurred will be stabilized and approved by the CVRWQCB prior to Caltrans filing a Notice of Termination. BMP selection for this project will be selected based on field conditions, changes to construction strategies, and regulatory requirements in order to protect listed species and their critical habitat. The project design team may specify BMPs to be utilized during construction in addition to, or in place of, other temporary measures selected by the contractor.

Equipment shall only be used that is in good working order and free of dripping or leaking engine fluids. Any necessary equipment washing will be conducted such that water is prevented from flowing into any drainage conveyance systems or receiving waters. In case of an accidental spill, an emergency response plan will be prepared and submitted to NMFS for review and approval at least 14 days prior to conducting any construction work. A spill prevention control and countermeasures plan will be on site and in place to handle any topside spills. The plan will include strict on-site handling rules to keep construction and maintenance materials from entering the river, including procedures related to refueling, operating, storing, and staging construction equipment, as well as preventing and responding to spills. The plan also will identify the parties responsible for monitoring the spill response. During construction, any spills will be cleaned up immediately according to the spill prevention and countermeasure plan. BMPs for spill containment measures (e.g. plastic sheeting, absorbent pads, and other containment devices) will be utilized during all construction activities in which direct contamination or runoff to the river could occur. Spill containment devices will be deployed around and beneath all over-water or work pad-mounted construction equipment. Supplemental equipment will be on site to collect and remove any spills. Discharge of turbid water into the Mokelumne River during construction activities will be prevented by filtering the discharge with a filter bag, diverting the water to a settling tank or infiltration area, and/or treating the water in a manner to ensure that discharges conform to the water quality requirements of the waste discharge permit issued by the CVRWQCB prior to entering receiving waters.

1.4.2 Paintersville Bridge

Pile driving and sound attenuation

Caltrans will use a NMFS-approved aquatic sound attenuation device to reduce the transmission of sound through water during pile driving activities. Sound attenuation devices that may be approved by NMFS include: 1) un-confined air bubble curtain, or 2) de-watered attenuation casing or confined air bubble curtain.

The Caltrans project engineer will be required to inspect the sound attenuation system for proper functionality and operation prior to each deployment and during deployment. Proper operation during deployment will be determined by the gauges on the monitoring system and by any other methods determined by the engineer. Air pressure and air flow meters will be calibrated by a private laboratory approved by the Caltrans engineer, prior to use in the air bubble curtain system. The condition of the sound attenuation system will be monitored, and daily inspection reports will be generated during pile driving activities and no less than every other day during periods of no activity.

The approved sound attenuation system must be operating prior to beginning pile driving at any given pile location. If the attenuation system fails, pile driving will cease immediately and may not resume until the Caltrans engineer has inspected the attenuation system and confirmed that it is fully functional and fully operational. A sound attenuation system will not be required for pile driving or casing installation activities using a vibratory hammer method. Pile driving equipment shall be isolated from the platform it is on. Isolation shall be such that noise from the pile driving operation is not transmitted through the platform into the water, generating excess noise. The platform supporting the pile driving equipment is not required to be contained within the attenuation system.

Construction planning and methods

Effects to listed species and critical habitat will be avoided and/or minimized by designating environmentally sensitive areas within the action area. Avoidance of these areas will be incorporated into all phases of construction, and information about these areas will be readily available and presented to all personnel involved with construction. For the purposes of this project, all areas outside of the action area will be considered environmentally sensitive. Establishment of environmentally sensitive areas will occur prior to construction and will remain in effect until all phases of the project are completed.

Before any work occurs in the action area, a NMFS-approved, qualified biologist will conduct an environmental awareness training to all construction personnel including contractors and sub-contractors. This training will brief them on the need to avoid and minimize effects to listed species and their designated critical habitat adjacent to and within the action area and penalties to applicable state and Federal permit requirements. The biologist will inform all construction personnel about the life history and habitat requirements of special status species that may occur in the action area, the importance of leaving habitat components intact and the terms and conditions stipulated by biological resource agencies as applicable (NMFS, CDFW, and USFWS). Training will cover general guidelines for minimizing and avoiding impacts to listed species and critical habitat. BMPs will be identified, explained, and written into construction specifications to avoid construction-related effects, sedimentation, pollution/contamination, and damage to riparian vegetation and other critical habitat components.

Discharge of turbid water into the Sacramento River during construction activities will be prevented by filtering the discharge with a filter bag, diverting the water to a settling tank or infiltration area, and/or treating the water in a manner to ensure that discharges conform to the water quality requirements of the waste discharge permit issued by the CVRWQCB prior to entering receiving waters.

The in-water work window, defined as any work occurring below the OHWM within the action area, shall occur between July 1st and no later than October 31st. Work below the OHWM may include installation and removal of a temporary work pad, removal of existing piles, and installation of new piles. This work window will serve to minimize and/or avoid potential adverse effects to listed species and their critical habitat.

BMPs for preventing sedimentation, turbidity, and pollution

Caltrans shall implement mitigation measures to contain construction-related material in manageable locations and prevent debris from entering surface waters during in-water work and for construction operations outside of receiving waters. Compliance with all construction site BMPs specified in the approved WPCP and any other permit conditions will be mandatory to minimize discharge of construction-related sediment and/or contaminants into the Sacramento River. In order to achieve this and reduce the potential for discharge, Caltrans shall follow all applicable guidelines and requirements outlined in the 2010 CSS (Caltrans 2010), Section 13, regarding water pollution control and general specifications for preventing, controlling, and abating water pollution in streams, waterways, and other bodies of water. Considerations for project-specific BMPs shall include waste management practices, especially for removed creosote-treated timbers; sediment control; and vehicle tracking control. BMPs will be based on best available science, as well as best conventional and best available technology. Caltrans staff shall perform routine inspections of the project area to verify that BMPs are properly implemented and maintained, and are operating effectively in accordance with design standards. BMPs and mitigation measures selected must meet the standards and objectives to minimize water pollution impacts set forth in the 2010 CSS.

BMPs will be implemented to prevent sedimentation and turbidity in all phases of the project. Specific measures for soil erosion will be implemented and in place prior to, during, and after construction to ensure that no silt or sediment enters the Sacramento River. Areas where a disturbance of soil has occurred will be stabilized and approved by the CVRWQCB prior to Caltrans filing a Notice of Termination. BMP selection for this project will be selected based on field conditions, changes to construction strategies, and regulatory requirements in order to protect listed species and their critical habitat. The project design team may specify BMPs to be utilized during construction in addition to, or in place of, other temporary measures selected by the contractor. Removal of the existing dolphin piles by cutting as opposed to vibratory extraction will reduce the disturbance of sediments, though it may cause an acute release of creosote to the river.

Equipment shall only be used that is in good working order and free of dripping or leaking engine fluids. Any necessary equipment washing will be conducted such that water is prevented from flowing into any drainage conveyance systems or receiving waters. In case of an accidental spill, an emergency response plan will be prepared and submitted to NMFS for review and approval at least 14 days prior to conducting any construction work. A spill prevention control and countermeasures plan will be on site and in place to handle any topside spills. The plan will include strict on-site handling rules to keep construction and maintenance materials from entering the river, including procedures related to refueling, operating, storing, and staging construction equipment, as well as preventing and responding to spills. The plan also will identify the parties responsible for monitoring the spill response. During construction, any spills will be cleaned up immediately according to the spill prevention and countermeasure plan. BMPs for spill containment measures (e.g. plastic sheeting, absorbent pads, and other containment devices) will be utilized during all construction activities in which direct contamination or runoff to the river could occur. Spill containment devices will be deployed around and beneath all over-water or work pad-mounted construction equipment. Supplemental equipment will be on site to collect and remove any spills. Discharge of turbid water into the Sacramento River during construction activities will be prevented by filtering the discharge with a filter bag, diverting the water to a settling tank or infiltration area, and/or treating the water in a manner to ensure that discharges conform to the water quality requirements of the waste discharge permit issued by the CVRWQCB prior to entering receiving waters.

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).

The combined action area for this project occurs on the Mokelumne River and the lower Sacramento River. Further descriptions of the action area for each of the sites is described below.

1.5.1 Mokelumne River Bridges

The Mokelumne River Bridges are the two parallel bridges on I-5 that cross the Mokelumne River at river mile (RM) 17.8 on the Sacramento/San Joaquin County line. The Mokelumne River Bridges are within the Bruceville 7.5-minute United States Geological Survey (USGS) Quadrangle (Quad). The center of the bridges over the Mokelumne River is located at 38.25481° N, -121.44788° W. The bridges each consist of 20 bents of five piles each. Two bents on each bridge are below the OHWM. The action area for this portion of the project extends 1,000 meters in either direction of the bridges. The action area includes the portion of the river determined to likely experience potential adverse effects resulting from the project including sedimentation, turbidity, and hydroacoustic impacts (Figure 1).

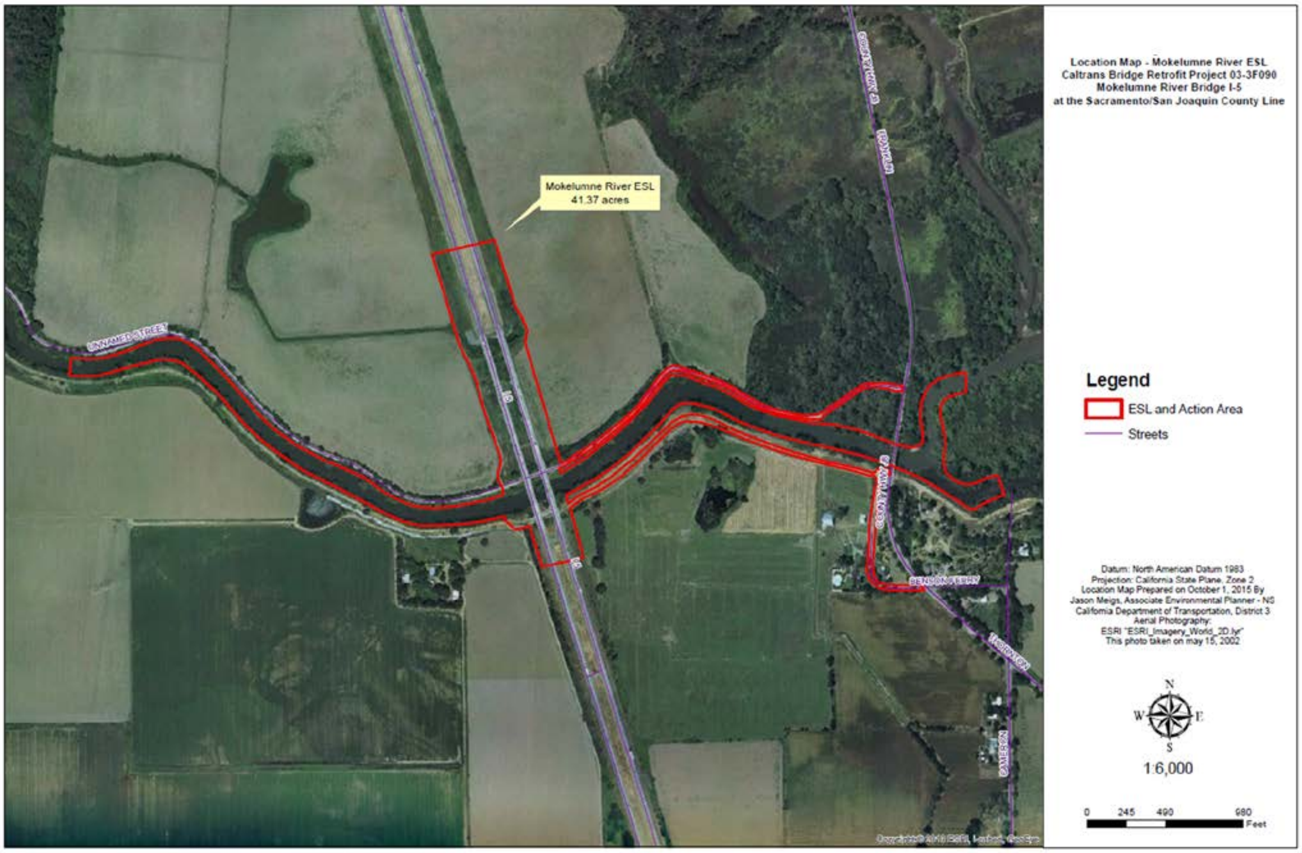


Figure 3. Mokelumne River Bridges action area (from Caltrans 2016).

1.5.2 Paintersville Bridge

The Paintersville Bridge is on State Route 160 over the Sacramento River at RM 35.6 near Paintersville. The Paintersville Bridge is within the Courtland 7.5-minute USGS Quad. The center of the Paintersville Bridge is located at 38.31865° N, -121.57766° W. The action area for this portion of the project extends 1,000 meters in either direction of the bridges. The action area includes the portion of the river determined to likely experience potential adverse effects resulting from the project including sedimentation, turbidity, and hydroacoustic impacts (Figure 2).

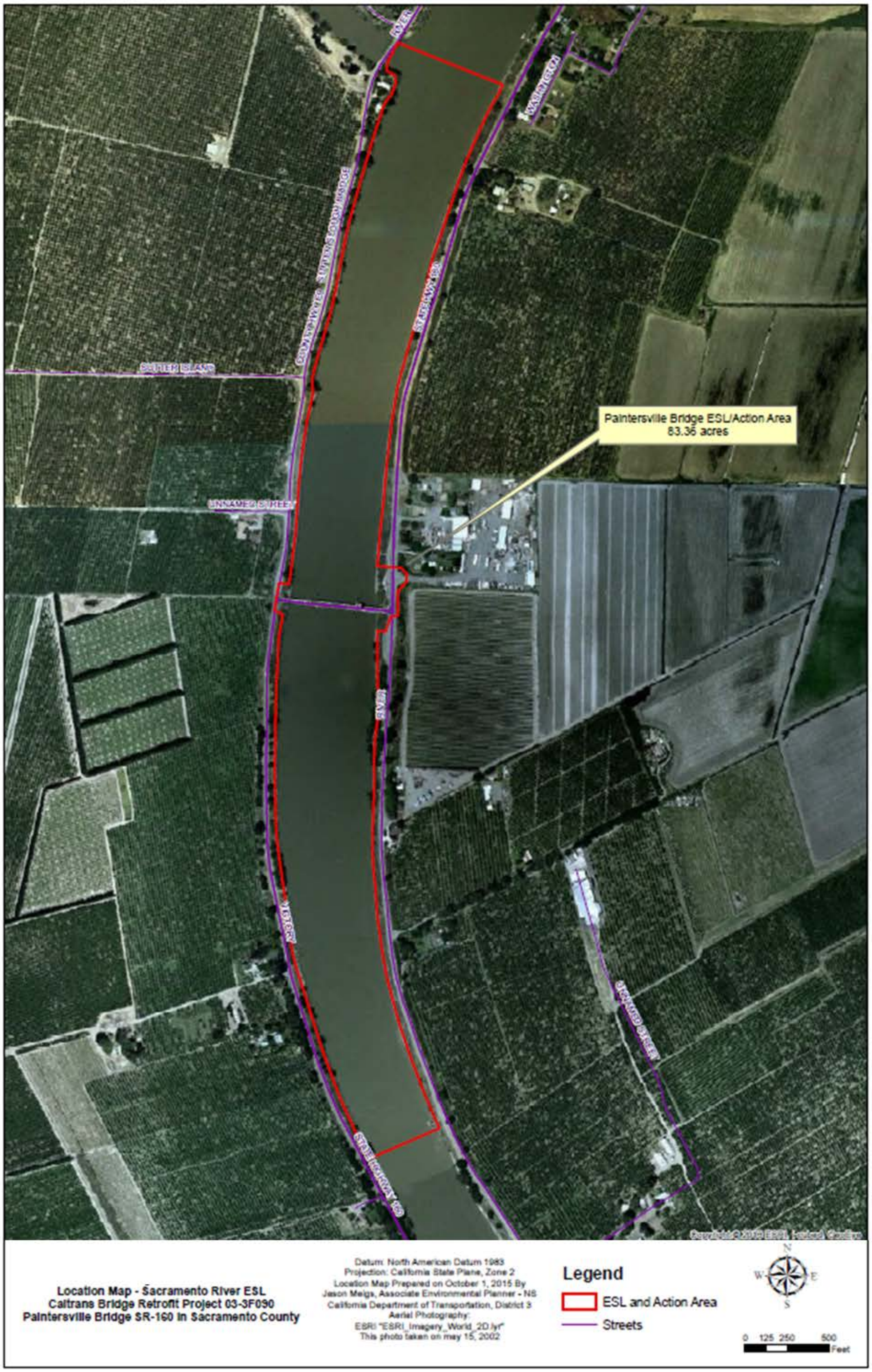


Figure 4. Paintersville Bridge over the Sacramento River action area (from Caltrans 2016).

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 designated critical habitat for Central Valley spring-run Chinook salmon or California Central Valley steelhead. The analysis is found in the "Not Likely to Adversely Affect" determinations section (2.11).

2.1 Analytical Approach

This BO 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 BO 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.

[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).

- 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 or biological features (PBFs) that help to form that conservation value. One factor affecting the rangewide status of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS of North American 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 (PCE) 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 BO, 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 (81 FR 33468). 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 (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 ESUs or 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

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

Central Valley 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

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

California Central Valley 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

Table 1. ESA listing history.

Species	Scientific Name	Original Final Listing Status	Current Final Listing Status	Critical Habitat Designated
Sacramento River winter-run Chinook salmon ESU	Oncorhynchus tshawytscha	1/4/1994 59 FR 440 Endangered	6/28/2005 70 FR 37160 Endangered	6/16/1993 58 FR 33212
Central Valley spring-run Chinook salmon ESU	*Oncorhynchus tshawytscha*	9/16/1999 64 FR 50394 Threatened	6/28/2005 70 FR 37160 Threatened	9/2/2005 70 FR 52488
California Central Valley steelhead DPS	*Oncorhynchus mykiss*	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488
Southern DPS of North American green sturgeon	*Acipenser medirostris*	4/7/2006 71 FR 17757 Threatened	4/7/2006 71 FR 17757 Threatened	10/9/2009 74 FR 52300

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 2011b) 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 2011b).

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 (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 2009a) 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 (PCBs), 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. Riparian and Floodplain Habitat that Provides for Successful Juvenile Development and Survival

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.* 2013).

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

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 2009a) 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 OHWM. In areas where the OHWM has not been defined, the lateral extent will be defined by the bankfull elevation which is 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 2011a); 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 2011a). 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 2011a) 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 OHWM. In areas where the OHWM has not been defined, the lateral extent will be defined by the bankfull elevation which is 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 2011c). 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 2011c).

There is a strong need for additional information about sDPS green sturgeon, especially with regard 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 OHWM. 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, Moyle *et al.* 1995). Eggs are likely to adhere to substrates, or settle into crevices between substrates (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Larvae exhibited a preference for benthic structure during laboratory studies (Van Eenennaam *et al.* 2001, Deng *et al.* 2002, Kynard *et al.* 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2007).

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.* 2007). 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 (Fairey *et al.* 1997, Foster *et al.* 2001a, Foster *et al.* 2001b, Kruse and Scarnecchia 2002, Feist *et al.* 2005). 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, the Central Valley, and the 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 (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.* 2007). 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 (75ºF). 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 (≥ 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.* 2007). Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters with depths of less than 10 meters, 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 feet 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 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, Roos 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 2004). Factors modeled by VanRheenen (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 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 2014).

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 occurs on the Mokelumne River and the mainstem of the lower Sacramento River. The action area encompasses a total area of approximately 124.73 acres, and includes the portion of the river determined to likely experience potential adverse effects resulting from the project including sedimentation, turbidity, and hydroacoustic impacts (Figure 1 and Figure 2).

2.3.1 Status of Listed Species in the Action Area

The Mokelumne River Bridges portion of the action area functions primarily as rearing habitat and as a migration corridor for CCV steelhead. CV spring-run Chinook and sDPS green sturgeon may also use the Mokelumne River for rearing. Various life stages of these species may be found within the action area throughout the year.

The Paintersville Bridge portion of the action area functions primarily as rearing habitat and as a migration corridor for Sacramento River winter-run Chinook, CV spring-run Chinook, CCV steelhead, and sDPS green sturgeon. Various life stages of these species may be found within the action area throughout the year.

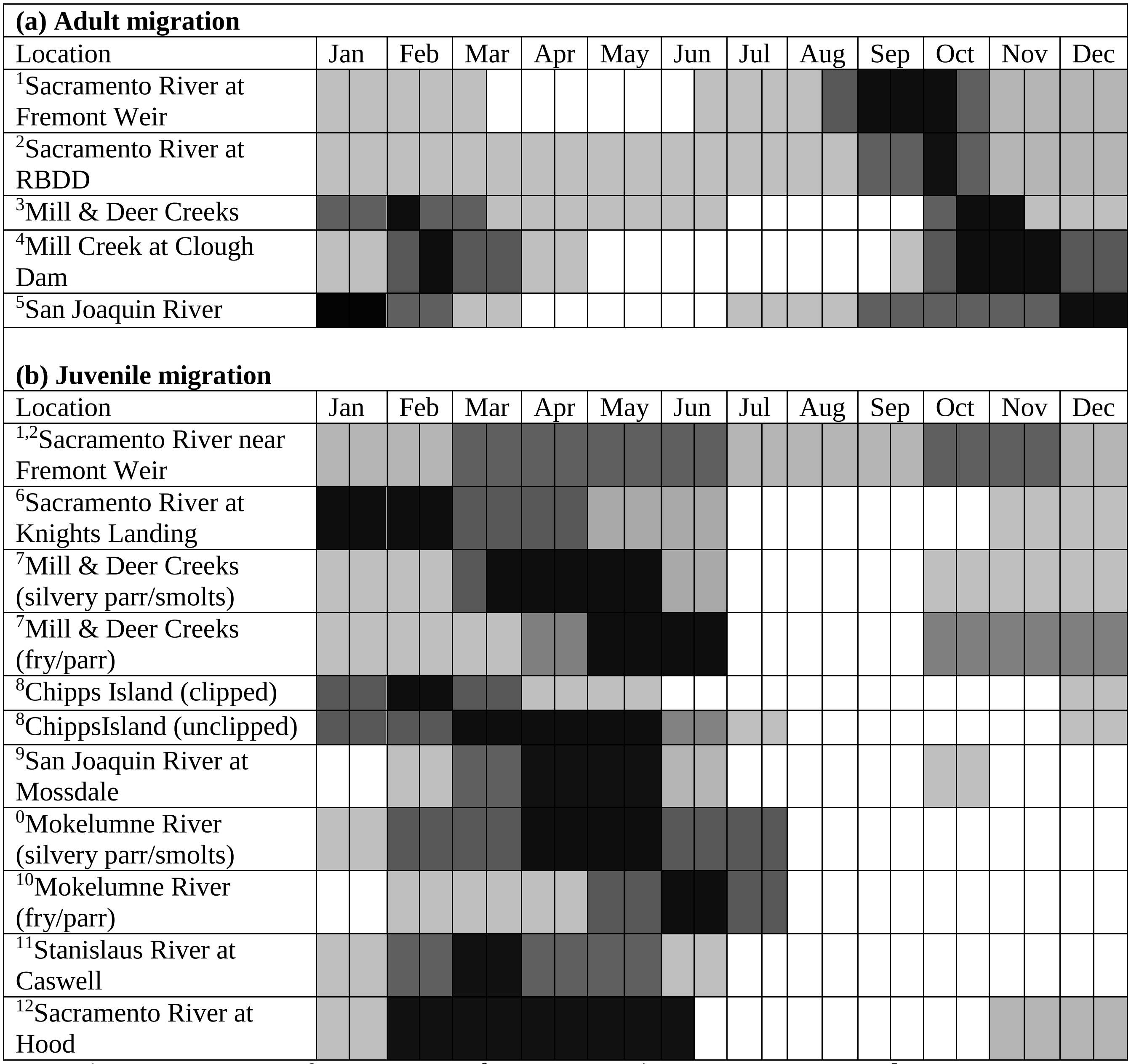
2.3.1.1 Mokelumne River Bridges

CV spring-run Chinook

The Mokelumne River may at times contain CV spring-run Chinook. When they do occur they are typically seen at Woodbridge Dam, significantly upstream of the action area, from April to June (M. Workman, *pers. comm.*). So, CV spring-run Chinook are not expected to be in the action area during the construction period.

CCV steelhead

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, NMFS 2011a). The Mokelumne River serves as a primary migratory corridor for both upstream and downstream migration, connecting spawning habitat within the San Joaquin River basin to the San Francisco Bay estuary and the Pacific Ocean. Adults can be found in the Mokelumne River primarily during the fall and winter seasons while juveniles occupy the river during the first half of the year (Figure 3). Juvenile rearing tends to occur in areas with cool, clear fast-moving water where riffle habitat is predominant over pool habitat (Moyle 2002). Therefore, it is more likely that juveniles found within the action area will be migrating rather than rearing. Juvenile steelhead may be present at medium relative abundance through July (Figure 3). Adults are not expected to be present in the action area in most of the proposed work window, but are present in low relative abundance in October (M. Workman, *pers. comm.*).



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

Relative Abundance: ■ = High ■ = Medium ■ = Low

Figure 5. The temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

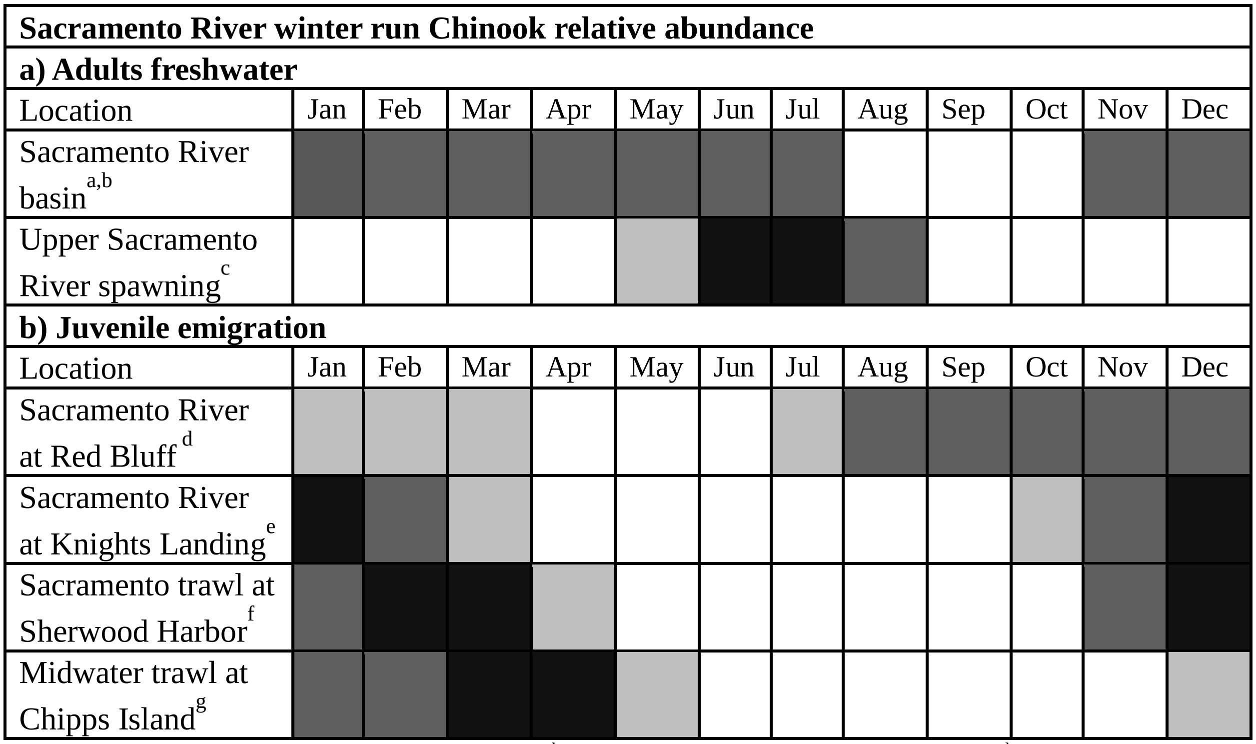
sDPS green sturgeon

The Mokelumne River could at times contain sDPS green sturgeon. However, sampling by East Bay Municipal Utility District (EBMUD) in the Mokelumne River has never encountered green sturgeon in their sampling (M. Workman, *pers. comm.*). So, sDPS green sturgeon are not expected to be in the action area during the construction period.

2.3.1.2 Paintersville Bridge

Sacramento River winter-run Chinook

Of the four anadromous fish species addressed in this BO, the Sacramento River winter-run Chinook ESU faces the greatest risk of extinction. This is due to a severe reduction in historical spawning habitat in the Sacramento River watershed. Listed as federally endangered, winter-run Chinook geographical distribution is confined to the mainstem Sacramento River, extending as far north as Keswick Dam. Spawning occurs below Keswick Dam and the mainstem Sacramento River serves as a migratory corridor. Figure 4 includes temporal occurrence and relative abundances for adults and juveniles in the mainstem Sacramento River and at Knights Landing, respectively. The Knights Landing data is indicative of juvenile presence and run timing in the action area, but the adult data is more indicative of upstream presence. Adult presence in the action area peaks in the winter and early spring, but they are not expected to be in the action area during the construction period.

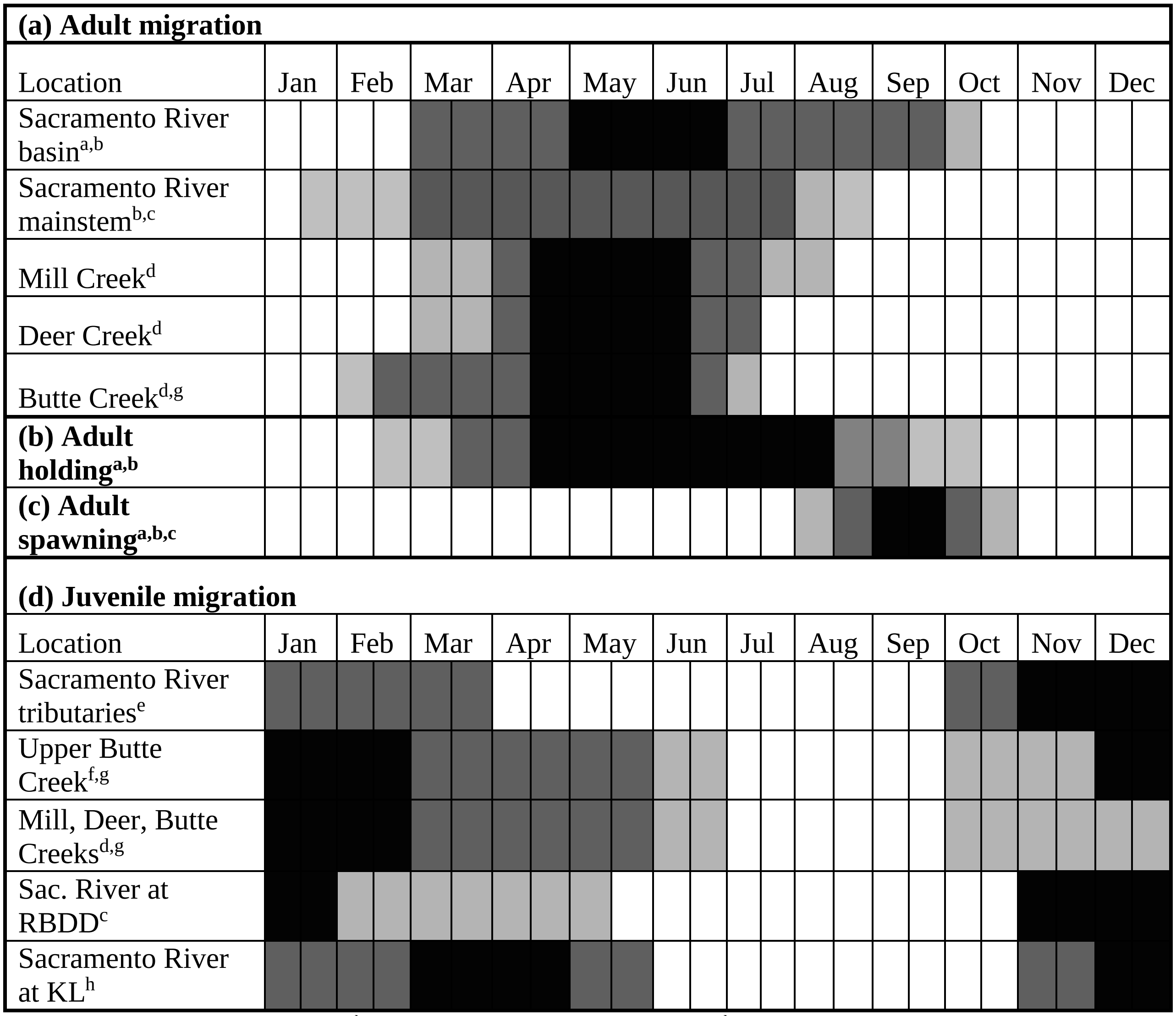


Sources: [a]Yoshiyama *et al.* (1998); Moyle (2002); [b]Myers *et al.* (1998) ; [c] Williams (2006) ; [d] Martin *et al.* (2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

Figure 6. The temporal occurrence of adult (a) and juvenile (b) winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

CV spring-run Chinook

The mainstem of the Sacramento River serves as a primary migratory corridor for both upstream and downstream migration of CV spring-run Chinook, connecting spawning habitat within the Sacramento River basin to the San Francisco Bay estuary and the Pacific Ocean. CV spring-run Chinook share a similar geographical distribution as well as many life history characteristics with CCV steelhead and the PBFs of their critical habitat are concurrently defined (see "*Status of Critical Habitat in the Action Area*" section). Figure 5 includes temporal occurrence and relative abundances for adults and juveniles in the mainstem Sacramento River and at Knights Landing, respectively. Similar to winter-run Chinook salmon, the Knights Landing data is indicative of juvenile presence and run timing in the action area, but the adult data is more indicative of upstream presence. Adult presence in the action area peaks in the winter and early spring, but they are not expected to be in the action area during the construction period.



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

Relative Abundance: ■ = High ■ = Medium ■ = Low

Figure 7. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

CCV steelhead

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, NMFS 2011a). The mainstem of the Sacramento River serves as a primary migratory corridor for both upstream and downstream migration, connecting spawning habitat within the

Sacramento River basin to the San Francisco Bay estuary and the Pacific Ocean. Adults can be found in the mainstem Sacramento River primarily during the fall and winter seasons while juveniles occupy the river year-round (Figure 3). Juvenile rearing tends to occur in areas with cool, clear fast-moving water where riffle habitat is predominant over pool habitat (Moyle 2002). Therefore, it is more likely that juveniles found within the action area will be migrating rather than rearing. Similar to winter- and spring-run Chinook salmon, the Knights Landing data is indicative of juvenile presence and run timing in the action area, but the adult data is more indicative of upstream presence. Adults are not expected to be present in the action area in June, but are present in low relative abundance in July, increasing to medium and high relative abundance in August and October (Hallock *et al.* 1957).

sDPS green sturgeon

The upper mainstem Sacramento River is the only area where consistent annual spawning by sDPS green sturgeon has been confirmed via the presence of eggs and larvae (Poytress *et al.* 2015). A migratory corridor is needed for returning adults to access spawning habitat upstream of the action area and the mainstem Sacramento River serves as a primary migration corridor. It also serves as a corridor for juveniles as they travel downstream towards the Delta. There is insufficient information available on how long juveniles rear in the mainstem Sacramento River, but it is likely that at least some juvenile rearing occurs in the river prior to their entry into the Delta. Therefore, the exact mechanisms of habitat utilization by juveniles within the action area is unknown, but we do expect subadult green sturgeon could be present in the action area year-round.

2.3.2 Status of Critical Habitat in the Action Area

2.3.2.1 Mokelumne River Bridges

CCV steelhead

The action area includes designated critical habitat for CCV steelhead. PBFs within the action area for these two species include (1) freshwater rearing sites and (2) freshwater migration corridors. Both of these PBFs have been degraded from their historical condition due to human activity on and near the Mokelumne River. Naturally occurring floodplain habitat has been largely removed in the vicinity of the action area due to bank revetment and other levee repair actions, limiting habitat value for juvenile rearing. Similarly, habitat complexity has been reduced due to revetment activities and removal of vegetation, reducing macroinvertebrate production, shelter from predators, and thermal refugia.

2.3.2.2 Paintersville Bridge

Sacramento River winter-run Chinook

Critical habitat for Sacramento River winter-run Chinook occurs in the action area. As defined in the Federal listing for this ESU, the essential physical and biological habitat features of Sacramento River winter-run Chinook salmon are: (1) migratory corridors for both upstream and downstream migration; (2) clean gravel for spawning; (3) adequate flow conditions for spawning, eggs, and larvae; (4) adequate temperature conditions for spawning, eggs, and larvae; (5) habitat and prey items that are free of contaminants; and (6) rearing habitat for juveniles. The features that occur within the action area are migratory corridors, habitat and prey items, and rearing habitat for juveniles. Each of these features has been degraded from historical conditions. Naturally occurring floodplain habitat has been largely removed in the vicinity of the action area due to bank revetment and other levee repair actions, limiting habitat value for juvenile rearing. Habitat complexity has been reduced due to revetment activities and removal of vegetation, reducing macroinvertebrate production, shelter from predators, and thermal refugia. The mainstem Sacramento River also contains inorganic nutrients and contaminants from agriculture and industrial practices throughout the Sacramento River watershed. These contaminants can greatly degrade water quality, especially in summer months.

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. PBFs within the action area for these two species include (1) freshwater rearing sites and (2) freshwater migration corridors. Both of these PBFs have been degraded from their historical condition due to human activity on and near the mainstem Sacramento River. Naturally occurring floodplain habitat has been largely removed in the vicinity of the action area due to bank revetment and other levee repair actions, limiting habitat value for juvenile rearing. Similarly, habitat complexity has been reduced due to revetment activities and removal of vegetation, reducing macroinvertebrate production, shelter from predators, and thermal refugia.

sDPS green sturgeon

Critical habitat for sDPS green sturgeon also occurs in the action area. The PBFs of sDPS green sturgeon critical habitat that are within the action area include (1) food resources, (2) adequate flow regime for all life stages, (3) water quality, (4) migratory corridors, (5) adequate water depth for all life stages, and (6) adequate sediment quality. The mainstem Sacramento River serves primarily as a migration corridor for green sturgeon. Insufficient data exists regarding the dynamics of juvenile rearing in the mainstem Sacramento River, but they are thought to exhibit at least some rearing behavior in the river before entering the Delta. Compared to the salmonid species addressed in this BO, the PBFs of green sturgeon critical habitat within the action area have not been adversely affected to the same degree. Because subadult and adult life stages are associated with benthic habitat, water quality and low flow conditions are likely the most deleterious factors influencing green sturgeon critical habitat PBFs. Due to a highly altered flow regime in the Sacramento River watershed and a recent drought event, flows through the action area are often inconsistent in summer months and have been greatly decreased from historical levels. Less is known about the habitat preference and reach-scale spatial orientation of juveniles, though they are most likely affected by these factors as well.

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 mainstem Sacramento River and the Mokelumne River have been degraded from their historic condition. Many anthropomorphic and naturally occurring factors have led to the decline of anadromous fish in the surrounding lotic ecosystem. Due to the construction of Keswick and Shasta dams as well as various other dams constructed on Sacramento River tributaries, flows and temperatures through the action area have been altered from their natural and historic regimes. Similarly the Camanche Dam has altered flow and temperature on the Mokelumne River. Altered flow regimes can influence migratory cues, water quality (including contaminants, dissolved oxygen, and nutrients for primary productivity), and temperature.

Drought conditions have played a significant role in the past 4 years as flows have decreased and temperatures have increased, leading to unfavorable environmental conditions in the river. This has resulted in direct and indirect impacts to listed fish as well as impacts to critical habitat. Increased temperatures have the potential to disrupt aquatic macroinvertebrate production, leading to declines in food availability in the action area (Ward and Stanford 1982). In addition, due to low flows, high concentrations of inorganic nutrients from agricultural activity may occur in the action area (Paerl *et al.* 2011). For CV spring-run Chinook and CCV steelhead, rearing site and migration corridor PBFs have been partially degraded as a result of flow and temperature alteration due to dam construction. Sacramento River winter-run PBFs affected by altered temperatures and flows include migratory corridors for both upstream and downstream migration, adequate flow conditions, adequate temperature conditions, and rearing habitat for juveniles. Affected PBFs for green sturgeon include adequate flow regime for all life stages, water quality, and migratory corridors.

Artificially-created levees have been constructed along the banks of the Sacramento and Mokelumne Rivers, substantially reducing the density of riparian vegetation within the action area. Riparian vegetation provides a host of ecosystem services and its removal has diminished habitat value within the action area. Riparian vegetation plays a key role in the conservation value of rearing habitat for all salmonid life stages. It provides shading to lower stream temperatures; increases the recruitment of large woody material into the river, increasing habitat complexity; provides shelter from predators; and enhances the productivity of aquatic macroinvertebrates (Anderson and Sedell 1979, Pusey and Arthington 2003). It has also been shown to directly influence channel morphology and may be directly correlated with improved water quality in aquatic systems (Schlosser and Karr 1981, Dosskey *et al.* 2010).

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

The Mokelumne River contains rearing habitat and a migration corridor for juvenile CCV steelhead. The Mokelumne River Bridges portion of the action area comprises approximately 2,000 linear meters of the river (1.24 RM). The Mokelumne River totals 59 RM from Camanche Dam to the Delta, making the Mokelumne River Bridges portion of the action area approximately 2.09% of the total length of the rearing habitat in the Mokelumne River. The

Mokelumne River is classified as a Core 2 watershed for CCV steelhead in the recovery plan (NMFS 2014). Core 2 watersheds have “populations [that] meet, or have the potential to meet, the biological recovery standard for moderate risk of extinction” (NMFS 2014). The mainstem Sacramento River contains rearing habitat and a migration corridor for the juvenile life stage of all species addressed in this BO. The Paintersville Bridge portion of the action area comprises approximately 2,000 linear meters of the river (1.24 RM) which may serve as rearing habitat for juveniles. The lower mainstem Sacramento River totals 302 RM from Keswick Dam to Rio Vista, making the Paintersville Bridge portion of the action area approximately 0.41% of the total length of rearing habitat in the Sacramento River. Although it is a small proportion of the total, the rearing habitat in the action area is important because it is downstream of major tributaries such as the Yuba River and Feather River, providing rearing opportunities for juveniles out-migrating from those systems. The mainstem Sacramento River is categorized as a Core 1 watershed for winter-run Chinook, a Core 2 population for CV spring-run, and a Core 2 population for CCV steelhead (NMFS 2014). Core 1 watersheds “possess the known ability or potential to support a viable population” (NMFS 2014).

Since it provides passage for all species between the Delta and their spawning habitat upstream, the migration corridor PBF is extremely important for their survival and recovery. Adult CCV steelhead return from the ocean via the Mokelumne River to spawn upstream. Adults of all listed anadromous fish species returning from the ocean to spawn utilize the Sacramento River mainstem to travel upstream into various areas of the watershed. CCV steelhead and CV spring-run access a number of spawning reaches upstream of the action area, including the Yuba River, Feather River, and smaller mainstem tributaries such as Battle Creek, Antelope Creek, Cottonwood Creek, and many others. Winter-run Chinook access spawning sites in the mainstem Sacramento River below Keswick Dam; and sDPS green sturgeon access sites in the mainstem Sacramento River below Keswick Dam, in the Feather River, and potentially in the Yuba River. Annual recruitment of each of these species is partially dependent on available passage through the action area as they occupy a large geographical range upstream.

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 Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon and/or the critical habitat of these species. 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 Bridge Seismic Retrofit Project.

2.4.1 Effects of the Proposed Action to Listed Fish Species

For our analysis on the effects of the proposed action to listed species, we have used the presence of species in the action area from the *Environmental Baseline* section of this BO to determine the species, life stage and specific months they are present for determining exposure to project impacts. The construction will generally occur during summer months when most species and life stages will not be present. Specifically, in the Sacramento River adult CCV steelhead may be present from July through October and subadult green sturgeon may be present throughout the construction season of July 1st to October 31st. Winter-run juveniles may be present between October 1 and October 31, but their relative abundance would be low, and we expect that the potential for adverse effects to them is improbable. CV spring-run Chinook are not expected to be in the action area during the in-water work window, so we expect that the potential for adverse effects to them is improbable. In the Mokelumne River juvenile steelhead may be present through July and adult steelhead may be present between October 1 and October 15.

The following sections analyze the effects to listed fish species due to: 1) pile driving and acoustic impacts, 2) increased sedimentation and turbidity, 3) construction-related effects, and 4) contaminants and pollution-related effects.

1) Pile Driving and Acoustic Impacts

Piles that are driven into river bed substrate propagate sound through the water which can damage a fish's swim bladder and other organs by causing sudden rapid changes in pressure, rupturing or hemorrhaging tissue in the bladder (Gisiner 1998, Popper *et al.* 2006). The swim bladder is the primary physiological mechanism which controls a fish's buoyancy. A perforated or hemorrhaged swim bladder has the potential to compromise the ability of a fish to orient itself both horizontally and vertically in the water column. This can result in diminished ability to feed, migrate, and avoid predators. Sensory cells and other internal organ tissue may also be damaged by noise generated during pile driving activities as sound reverberates through a fish's viscera (Gaspin 1975). In addition, morphological changes to the form and structure of auditory organs (saccular and lagenar maculae) have been observed after intense noise exposure (Hastings 1995). It is important to note that acute injury resulting from acoustic impacts should be scaled based on the mass of a given fish. Juveniles and fry have less inertial resistance to a passing sound wave and are therefore more at risk for non-auditory tissue damage (Popper and Hastings 2009).

Fish can also be injured or killed when exposed to lower sound pressure levels for longer periods of time. Hastings (1995) found death rates of 50 percent and 56 percent for gouramis (*Trichogaster sp*.) when exposed to continuous sounds at 192 dB at 400 Hz and 198 dB at 150 Hz, respectively, and 25 percent for goldfish (*Carassius auratus*) when exposed to sounds of 204 dB at 250 Hz for two hours or less. Hastings (1995) also reported that acoustic "stunning," a potentially lethal effect resulting in a physiological shutdown of body functions, immobilized gourami within eight to thirty minutes of exposure to the aforementioned sounds.

Multiple studies have shown responses in the form of behavioral changes in fish due to human-produced noise (Wardle *et al.* 2001, Slotte *et al.* 2004, Popper and Hastings 2009).

Instantaneous behavioral responses may range from mild awareness to a startle response. Fish may also exhibit movements that displace them from a position normally occupied in their habitat for short or long durations. Depending on the innate behavior that is being disrupted, the direct and indirect adverse effects could be varied. This is of particular concern for juvenile fish as there are innate behaviors that are essential to their maturation and survival such as feeding, sheltering, and migratory patterns. An example of a significant, direct adverse effect would be cessation or alteration of migratory behavior. In the context of the proposed action area, the migratory behavior of juvenile salmonids and green sturgeon may be affected by various pile driving and acoustic impacts. Though pile driving may affect migratory behavior, it is not expected to prevent salmonids and sturgeon from passing upstream or downstream because pile driving will not be continuous through the day, and will not occur at night, when the majority of fish migrate.

Based on recommendations from the Fisheries Hydroacoustic Working Group (FHWG), NMFS uses a dual metric criteria to assess onset of injury for fish exposed to pile driving sounds (FHWG 2008). For a single strike, the peak exposure level above which injury is expected to occur is 206 dB. However, cumulative acoustic effects are expected for any situation in which multiple strikes are being made to an object with a single strike peak dB level above the effective quiet threshold of 150 dB. So, the accumulated sound exposure level (SEL) level above which injury of fish is expected to occur is 187 dB for listed fish not less than 2 grams and 183 dB for fish less than 2 grams. If either the peak SEL or the accumulated SEL threshold is exceeded, then physical injury is expected to occur. Behavioral effects may still occur below these thresholds for injury. NMFS uses a 150 dB root mean square (RMS) threshold for behavioral responses in salmonids and green sturgeon. Though the dB value is the same, the 150 dB RMS threshold for behavioral effects is unrelated to the 150 dB effective quiet threshold.

Mokelumne River Bridges

The CISS piles for the bent cap extension retrofit on the Mokelumne River Bridges are proposed to be installed using an impact hammer which will be operated from a temporary work pad. The proposed action includes installation of eight 48-inch CISS piles below the OHWM, two piles per bent for four bents. For the purposes of Caltrans' effects analysis, an APE D100-42 hammer was used to analyze potential driving conditions and potential adverse effects to listed fish species. According to an October 2012 update to the Caltrans hydroacoustic compendium (Caltrans 2012), the unmitigated installation of 48-inch CISS piles with the use of an impact hammer will result in single-strike sounds levels of 205 dB_{peak} and 195 dB_{RMS} at 10 meters (32.8 feet) from the pile with an estimated SEL of 185 dB. With the use of a bubble curtain, which is assumed to provide a minimum 5 dB of sound reduction, the maximum single-strike sound level is conservatively estimated to be 200 dB_{peak} and 190 dB_{RMS} at 10 meters (32.8 feet) from the pile and an estimated SEL of 180 dB. For both the attenuated and unattenuated scenarios the estimated peak sound level is below the interim threshold for fish injury for a single strike. However, cumulative acoustic effects are expected for any situation in which multiple strikes are being made to an object with a single strike peak dB level above the effective quiet threshold of 150 dB.

Under continuous operation during an eight hour day, the impact hammers used for this analysis can deliver 16,320 to 25,440 blows per day. Caltrans used the lower bound of this, 16,320, for their analyses of acoustic effects. Distances to the thresholds for acoustic effects at the Mokelumne Bridges are summarized in Table 2. If the CISS piles are installed with bubble curtain attenuation, physical injury due to cumulative sound exposure is likely to occur out to 1,000 meters for fish of any size, and non-injurious behavioral responses are expected out to 4,642 meters. Caltrans estimates that each pile may require up to 15,600 strikes. So, for the eight piles below the OHWM of the Mokelumne River, a total of 124,800 strikes may be required.

Table 2. Acoustic effects at the Mokelumne River Bridges.

Pile Type	Driver Type	Strikes Per Day	Reference Distance (m)	Attenuation (dB)	Peak (dB)	SEL (dB)	RMS (dB)	Distance (m) to Threshold			
								Onset of Physical Injury			Behavior
								Peak dB	Cumulative SEL dB		RMS dB
									Fish >2 g	Fish < 2 g	
								206 dB	187 dB	183 dB	150 dB
48-inch CISS	Impact	16320	10	0	205	185	195	9	2154	2154	10000
48-inch CISS	Impact	16320	10	5	200	180	190	4	1000	1000	4642

Paintersville Bridge

The Paintersville Bridge site will require the installation of a temporary work trestle. The temporary work trestle will be supported by 240 18-inch to 20-inch steel piles. Caltrans expects that the piles for the temporary trestle will be installed using an impact hammer similar to the Delmag D36-32 or APE D100-42. Since the acoustic effects will be greater for 20-inch piles, those will be considered in this BO. According to Caltrans 2012, the unmitigated installation of 20-inch steel piles with the use of an impact hammer will result in single-strike sounds levels of 208 dB_{peak} and 187 dB_{RMS} at 10 meters (32.8 feet) from the pile with an estimated SEL of 176 dB. With the use of a bubble curtain, which is assumed to provide a minimum 5 dB of sound reduction, the maximum single-strike sound level is conservatively estimated to be 203 dB_{peak} and 182 dB_{RMS} at 10 meters (32.8 feet) from the pile and an estimated SEL of 171 dB.

Each of the four proposed new pier collars will be supported by two 96-inch diameter CISS piles, for a total of eight 96-inch diameter CISS piles. These piles are proposed to be installed using an impact hammer which will be operated from the temporary trestle. Caltrans expects that a hammer similar to the APE D180-42 may be used to drive the CISS piles. According to Caltrans 2012, the unmitigated installation of 96-inch CISS piles with the use of an impact hammer will result in single-strike sounds levels of 220 dB_{peak} and 205 dB_{RMS} at 10 meters (32.8 feet) from the pile with an estimated SEL of 195 dB. With the use of a bubble curtain, which is assumed to provide a minimum 5 dB of sound reduction, the maximum single-strike sound level is conservatively estimated to be 215 dB_{peak} and 200 dB_{RMS} at 10 meters (32.8 feet) from the pile and an estimated SEL of 190 dB. For both the attenuated and unattenuated scenarios the estimated peak sound level is above the interim threshold for fish injury for a single strike. Further, cumulative acoustic effects are expected for any situation in which multiple strikes are being made to an object with a single strike peak dB level above the effective quiet threshold of 150 dB.

The 56 piles required for the replacement dolphins will likely be plastic piles or 20-inch steel piles. Since the acoustic effects will be greater for 20-inch piles, those will be considered in this BO. These effects will be the same as those for the 20-inch piles used for the temporary work trestle listed above.

For the acoustic analysis for the 20-inch steel pipes, Caltrans estimated 17,280 strikes per day using the Delmag D36-32 impact hammer. Distances to the thresholds for acoustic effects at the Paintersville Bridge are summarized in Table 3. If the 20-inch steel piles are installed with bubble curtain attenuation, physical injury due to cumulative sound exposure is likely to occur out to 251 meters for fish of any size, and non-injurious behavioral responses are expected out to 1,359 meters. Caltrans estimates that each pile may require up to 1,000 strikes. So, for the 240 20-inch piles for the temporary trestles, a total of 240,000 strikes may be required. Since Caltrans plans to build a trestle from one bank one season and the other bank the following season, these strikes will likely be conducted over two working seasons. Assuming 1,000 strikes per pile, the installation of the dolphins will require another 56,000 strikes. So, a total of 296,000 strikes may be required for the installation of all the 20-inch steel piles at the Paintersville Bridge site.

For the 96-inch CISS piles, Caltrans used an estimate of 16,320 strikes per day with the APE D180-42 impact hammer. Distances to the thresholds for acoustic effects at the Paintersville Bridge are summarized in Table 3. If the 96-inch CISS piles are installed with bubble curtain attenuation, physical injury due to cumulative sound exposure is likely to occur out to 4,642 meters for fish of any size, and non-injurious behavioral responses are expected out to 21,544 meters. Caltrans estimates that each pile may require up to 10,000 strikes. So, for the 8 96-inch CISS piles, a total of 80,000 strikes may be required.

Table 3. Acoustic effects at the Paintersville Bridge.

Pile Type	Driver Type	Strikes Per Day	Reference Distance (m)	Attenuation (dB)	Peak (dB)	SEL (dB)	RMS (dB)	Distance (m) to Threshold			
								Onset of Physical Injury			Behavior
								Peak dB	Cumulative SEL dB		RMS dB
									Fish >2 g	Fish < 2 g	
								206 dB	187 dB	183 dB	150 dB
20-inch steel pipe	Impact	17280	10	0	208	176	187	14	541	541	2929
20-inch steel pipe	Impact	17280	10	5	203	171	182	6	251	251	1359
96-inch CISS	Impact	16320	10	0	220	195	205	86	10000	10000	46416
96-inch CISS	Impact	16320	10	0	215	190	200	40	4642	4642	21544

2) Increased Sedimentation and Turbidity

Increased sedimentation and turbidity may result from a number of sources associated with the proposed project. The use of heavy equipment in and along the river banks, removing piles, and driving piles may cause turbidity within the action area. Sedimentation and turbidity are expected to have varying effects among different listed species and different life stages that are expected to be present in the action area during the proposed in-water construction window. CCV steelhead, CV spring-run, and sDPS green sturgeon juveniles and adults may be present as well as Sacramento River winter-run adults within the Sacramento River portion of the action area. CCV steelhead juveniles and adults may be present in the Mokelumne River portion of the action area. High levels of suspended sediment reduces the ability of listed fish to feed and respire, resulting in increased stress levels and reduced growth rates, and a reduced tolerance to fish diseases and toxicants (Waters 1995). None of these species are known to spawn in the action area, therefore egg life stages are not expected to be present. Juvenile CCV steelhead and CV spring-run are known to rear in and migrate through the Sacramento River portion of the action area, and may be present during the scheduled in-water work window. Juvenile CCV steelhead are known to rear in and migrate through the Mokelumne River portion of the action area, and may be present during the scheduled in-water work window. In a lab study, juvenile steelhead and coho salmonids were found to occupy a parcel of water by choice between 57 and 77 nephelometric turbidity units (NTU) (Sigler *et al.* 1984). This result suggests that juvenile salmonids may not exhibit avoidance behavior in low to moderate turbidities during migration. 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 1993). 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 (Sigler *et al.* 1984, Suttle *et al.* 2004, Kemp *et al.* 2011).

Although less is known about the timing of rearing and migration of sDPS green sturgeon, both adult and juvenile life stages are known to utilize the Sacramento River portion of the action area as a migration corridor and may exhibit rearing behavior there as well. Less is known about the specific detrimental physical and physiological effects of sedimentation and turbidity to sturgeon. However, it is thought that high levels of turbidity can generally result in gill fouling, reduced temperature tolerance, reduced swimming capacity and reduced forage capacity in lotic fishes (Wood and Armitage 1997).

Based on the proposed project description, sedimentation events and elevation of turbidity associated with construction are expected to be minor and transient in nature. Also, avoidance and minimization techniques will be implemented in this project as well as BMPs pertaining to the prevention of sedimentation and turbidity. These actions will minimize the extent of adverse effects associated with the proposed action.

3) Construction-related Effects

Construction-related activities have the potential to result in injury or death to listed fish species. Construction-related effects may include debris falling into the active channel, tools and/or equipment falling into the active channel, or noise generated by displaced rock and sediment and the operation of construction machinery. Adult CCV steelhead, CV spring-run, and Sacramento River winter-run are known to migrate through the Sacramento River portion of the action area; juvenile CCV steelhead and CV spring-run are known to rear in and migrate through the Sacramento River portion of the action area; and both adult and juvenile life stages of sDPS green sturgeon are known to utilize the action area as a migration corridor and may exhibit rearing behavior there as well. Juvenile CCV steelhead are known to rear in the Mokelumne River portion of the action area; adult and juvenile CCV steelhead are known to migrate through the Mokelumne River portion of the action area. Any of these species/life stages may be present during the scheduled in-water work window and may be adversely affected by construction-related effects. BMPs, avoidance, and minimization techniques will be implemented, minimizing the probability of construction-related effects in the action area.

Construction-related effects have the potential for direct or indirect adverse effects to species/life stages that may be present in the action area during construction. Adults and juveniles could potentially encounter falling debris, be hit or become trapped by piles as they are being installed or removed, or may become trapped between the construction barge and the bottom, which could cause physical injury or death, or construction-related noise, which may alter behavior.

Fish may also exhibit movements that displace them from a position normally occupied in their habitat for short or long durations. Depending on the innate behavior that is being disrupted, the direct and indirect adverse effects could be varied. This is of particular concern for juvenile fish as there are innate behaviors that are essential to their maturation and survival such as feeding, sheltering, and migratory patterns. An example of a significant, direct adverse effect would be cessation or alteration of migratory behavior. In the context of the proposed action area, the migratory behavior of juvenile salmonids and green sturgeon may be affected by various construction-related effects.

4) Contaminants and Pollution-related Effects

Seismic retrofitting, pile removal, and pile driving as described in 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, creosote from the existing dolphins at the Paintersville Bridge, 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 the Sacramento and Mokelumne Rivers. However, unlike sedimentation, turbidity, and construction-related effects; potential pollution-related effects may be persistent in the action area and may affect multiple life stages if they were to occur.

Incursion of contaminants into the Sacramento River portion of the action area has the potential to directly or indirectly affect CCV steelhead, CV spring-run Chinook, Sacramento River winter run, and/or sDPS green sturgeon that may be migrating or rearing in the Sacramento River portion of the action area at the time of a pollution event or possibly afterwards. Incursion of contaminants into the Mokelumne River portion of the action area has the potential to directly or indirectly affect CCV steelhead that may be migrating or rearing in the Mokelumne River portion of the action area at the time of a pollution event 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 2008). 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 flatfishes (order Pleuronectiformes) and have carcinogenic, mutagenic and cytotoxic effects (Johnson *et al.* 2002). The exact toxicological effects of PAHs in juvenile salmonids are 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). The removal of the existing dolphins at the Paintersville Bridge consisting of creosote-treated timber piles has the potential to release creosote, and therefore PAHs, into the Mokelumne River. CCV steelhead adults and juveniles, CV spring-run Chinook adults and juveniles, Sacramento River winter run adults, and sDPS green sturgeon adults and juveniles are expected to be present in the Sacramento River portion of the action area during construction activities and would potentially be directly affected by a pollution event. Winter-run juveniles could be indirectly affected by a pollution event if contaminants were to settle within substrate in the active channel of the Sacramento River that may become disturbed at a later time. CCV steelhead adults and juveniles are expected to be present in the Mokelumne River portion of the action area during construction activities and would potentially be directly affected by a pollution event. Caltrans may use bentonite as a lubricant for pile placement and an accidental release may occur. Bentonite is potentially lethal to fish and has been shown to reduce growth rates or increase emigration rates in steelhead and Coho salmon when exposed to 125 to 175 mg/L of bentonite (Sigler *et al.* 1984).

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.

5) De-watering of Piles and/or Attenuation Casing

De-watering of the hollow space within the new steel piles or CISS piles may occur. Additionally, de-watered attenuation casings may be used to minimize acoustic impacts to fish. There is some potential for fish to be trapped within the piles or attenuation casing. Caltrans has determined that recovery and relocation of fish entrapped within the piles or attenuation casing is not feasible.

Avoidance and minimization measures for de-watering primarily consist of timing the in-water work to avoid sensitive life stages.

2.4.2 Effects of the Proposed Action to Critical Habitat

2.4.2.1 Mokelumne River Bridges

Critical habitat has been designated in the Mokelumne River Bridges portion of the action area for California Central Valley steelhead. The PBFs within the action area for CCV steelhead are (1) freshwater rearing sites and (2) freshwater migration corridors.

Freshwater rearing sites and freshwater migration corridors for CCV steelhead are not likely to be affected by the proposed action. Due to the installation of the 48-inch CISS piles there will be a permanent increase to in-stream obstructions from the new piles, but, given the width of the river and that the piles are aligned with each other in pairs along the trajectory of the river flow, this should not negatively impact the migration corridors in either direction for CCV steelhead. The proposed action is not likely to adversely affect the critical habitat of CCV steelhead.

2.4.2.2 Paintersville Bridge

Critical habitat has been designated in the Paintersville Bridge portion of the action area for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and southern DPS of green sturgeon. The PBFs that occur within the action area for Sacramento River winter-run Chinook salmon are: (1) migratory corridors for both upstream and downstream migration, (2) habitat and prey items that are free of contaminants, and (3) riparian habitat for juvenile rearing. The PBFs within the action area for sDPS green sturgeon are: (1) food resources, (2) adequate flow regime for all life stages, (3) water quality, (4) migratory corridors, (5) adequate water depth for all life stages, and (6) adequate sediment quality. The PBFs within the action area for CV spring-run Chinook and CCV steelhead are (1) freshwater rearing sites and (2) freshwater migration corridors.

Freshwater rearing sites and freshwater migration corridors for CV spring-run Chinook and CCV steelhead are not likely to be affected by the proposed action. Due to the installation of the 96-inch CISS piles there will be a permanent increase to in-stream obstructions from the new piles, but, given the width of the river and that the piles are aligned with each other in pairs and with the existing piles along the trajectory of the river flow, this should not negatively impact the migration corridors in either direction for CV spring-run Chinook or CCV steelhead. The proposed action is not likely to adversely affect the critical habitat of CV spring-run Chinook or CCV steelhead.

Migratory corridors for winter-run Chinook and sDPS green sturgeon are not likely to be affected by the proposed action. Due to the installation of the 96-inch CISS piles there will be a permanent increase to in-stream obstructions from the new piles, but, given the width of the river and that the piles are aligned with each other in pairs and with the existing piles along the trajectory of the river flow, this should not negatively impact the migration corridors in either direction for winter-run Chinook or sDPS green sturgeon.

Habitat and prey items for winter-run Chinook may be temporarily affected by contaminants due to the proposed action. Habitat may be contaminated via increased turbidity and sediments in the water column due to drilling pile driving, pile removal, and work along river banks and in the river. Additionally, water, sediments, and potential prey items may become contaminated from petrochemicals from construction equipment or from PAHs as the current creosote-treated timber piles of the current dolphins are removed. Contamination is not likely to persist after construction work is complete, so the habitat and prey items will likely not be permanently affected due to the proposed action. The replacement of the current creosote-treated timber piles with plastic or steel piles will permanently reduce the potential for PAH contamination of the water from the dolphin piles for this segment of the Sacramento River, nearby sediments, and nearby prey. Avoidance and mitigation efforts for sedimentation and contamination are discussed in section 1.4.

The proposed action is not likely to affect riparian or flood plain habitat necessary for juvenile rearing of winter-run Chinook. Removal of riparian vegetation is not expected to occur at the Paintersville Bridge portion of the action area, and flood plain habitat does not occur in the action area.

The proposed action is not likely to affect flow conditions for sDPS green sturgeon within the action area. The presence of the temporary trestle during the in-water work window may temporarily affect localized flow conditions since the trestle will be anchored via piles driven into the riverbed.

Food resources for sDPS green sturgeon may be temporarily affected by contaminants due to the proposed action. Potential prey items may become contaminated from petrochemicals from construction equipment or from PAHs as the current creosote-treated timber piles are removed. Contamination is not likely to persist after construction work is complete, so food resources will likely not be permanently affected due to the proposed action. The replacement of the current creosote-treated timber piles with plastic or steel piles will permanently reduce the potential for PAH contamination of the water from the dolphin piles for this segment of the Sacramento River and nearby prey. Avoidance and mitigation efforts for sedimentation and contamination are discussed in section 1.4.

The proposed action may affect water quality for sDPS green sturgeon. The water may be contaminated via increased turbidity and sediments in the water column due to pile driving, pile removal, and work along the river banks and in the river. Additionally, the water may become contaminated from petrochemicals from construction equipment or from PAHs as the current creosote-treated timber piles are removed. Contamination is not likely to persist after construction work is complete, so the water will likely not be permanently affected due to the proposed action. The replacement of the current creosote-treated timber piles with plastic or steel piles will permanently reduce the potential for PAH contamination of the water from the fender piles for this segment of the Sacramento River. Avoidance and mitigation efforts for sedimentation and contamination are discussed in section 1.4.

Sediment quality for sDPS green sturgeon may be temporarily affected by contaminants due to the proposed action. Sediments may become contaminated from petrochemicals from construction equipment or from PAHs as the current creosote-treated timber piles are removed. Contamination is not likely to persist after construction work is complete, so the habitat and prey items will likely not be permanently affected due to the proposed action.

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.

2.5.1 Water Diversions

Water diversions for municipal and industrial use are found in action area. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species.

2.5.2 Increased Urbanization

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

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

2.5.3 Rock Revetment and Levee Repair Projects

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

2.5.4 Global Climate Change

The world is about 1.3°F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (IPCC 2007). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes *et al.* 1998). Using objectively analyzed data Liu and Huang (2000) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g*., salt marsh, riverine, mud flats) affecting listed salmonid and green sturgeon PBFs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Petersen and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the CV has been modeled to have an increase of between 2 and 7 degrees Celsius by 2100, with a drier hydrology predominated by rainfall rather than snowfall (Dettinger 2004, Hayhoe *et al.* 2004, VanRheenen 2004, Stewart *et al.* 2005). This will alter river runoff patterns and transform the tributaries that feed the CV from a spring and summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This will truncate the period of time that suitable cold-water conditions exist downstream of existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures downstream of reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and CCV steelhead) that must hold and/or rear downstream of the dam over the summer and fall periods.

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 Effects of the Action) to the environmental baseline (section 2.3 Environmental Baseline) and the cumulative effects (section 2.5 Cumulative Effects), taking into account the status of the species and critical habitat (section 2.2 Rangewide Status of the Species and Critical Habitat), 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.

Sacramento River winter-run Chinook ESU, CV spring-run Chinook ESU, CCV steelhead DPS, and sDPS green sturgeon have experienced significant declines in abundance and available habitat in the California Central Valley relative to historical conditions. The status of the species section (2.2 Rangewide Status of the Species and Critical Habitat) details the current range-wide status of these ESUs and DPSs and their critical habitat. The environmental baseline section (2.3 Environmental Baseline) describes the current baseline conditions found in the Sacramento and Mokelumne Rivers, where the proposed action is to occur. Section 2.5.4 Global Climate Change discusses the vulnerability of listed species and critical habitat to climate change projections in the California Central Valley and specifically in the Sacramento and Mokelumne Rivers. Reduced summer flows and increased water temperatures will likely be exacerbated by increasing surface temperatures in the Sacramento and Mokelumne River basins. The Sacramento and Mokelumne Rivers are highly manipulated systems with flow and temperature regimes that differ drastically from their historical condition. Cumulative effects are likely to include decreased water flow, increased river traffic, and increased stormwater runoff from increased urbanization and from concurrent state and local projects in the action area.

Effects of the Proposed Action to Listed Species

The proposed action has the potential to affect adult CCV steelhead, and subadult sDPS green sturgeon. Pile driving is expected to result in adverse effects due to behavioral effects, injury, or death from acoustic effects. Behavioral effects from pile driving may include temporary disruptions in the feeding, sheltering, and migratory behavior of adult and juvenile salmon, steelhead, and sturgeon. These disruptions may injure or kill fish by causing reduced growth for subadult sturgeon and increased susceptibility to predation for subadult sturgeon and adult steelhead. Pile driving is also not expected to prevent salmonids and sturgeon from passing upstream or downstream because pile driving will not be continuous through the day, and will not occur at night, when the majority of fish migrate. Pile driving effects will be minimized by avoiding the peak migration periods of listed anadromous salmonids. Pile driving and pile removal are likely to result in sediment and turbidity pulse events which may result in adverse effects to adult CCV steelhead and subadult sDPS greens sturgeon due to increased activity, gill fouling, and reduced foraging capability. Incubating eggs are also susceptible to a multitude of adverse effects resulting from sedimentation, although eggs are expected to hatch prior to the commencement of activity in the action area. Construction-related effects may also occur as a result of construction equipment operation in and near the river. All species and life stages present will likely be impacted by adverse construction-related effects. Contaminants and pollution events have the potential to occur in the action area and may impact all species and life stages considered in this consultation. BMPs, minimization and avoidance measures will be implemented for each major action described in the proposed action and will aid in minimizing direct impacts to listed fish in the Sacramento and Mokelumne Rivers.

Effects of the Proposed Action to Critical Habitat

Critical habitat has been designated in the action area for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and southern DPS of green sturgeon. The PBFs that occur within the action area for Sacramento River winter-run Chinook salmon are: (1) migratory corridors for both upstream and downstream migration, (2) habitat and prey items that are free of contaminants, and (3) riparian habitat for juvenile rearing. The PBFs within the action area for sDPS green sturgeon are: (1) food resources, (2) adequate flow regime for all life stages, (3) water quality, (4) migratory corridors, (5) adequate water depth for all life stages, and (6) adequate sediment quality. The PBFs within the action area for CV spring-run Chinook and CCV steelhead are (1) freshwater rearing sites and (2) freshwater migration corridors. The proposed action is not likely to affect the critical habitat of CV spring-run Chinook or CCV steelhead.

Survival and Recovery

The Sacramento River contains spawning populations of Sacramento River winter-run Chinook, CV spring-run Chinook, CCV steelhead, and sDPS green sturgeon, making it an important river in terms of range-wide recovery for these species. Further, the Sacramento River is the only spawning location for Sacramento River winter-run Chinook and the only known spawning location for sDPS green sturgeon. The Mokelumne River contains spawning populations of CCV steelhead. The adverse effects to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and North American green sturgeon within the action area are not expected to affect the overall survival and recovery of the ESUs/DPSs. This is largely due to the fact that although construction may cause adverse effects to some listed salmonids, the impacts will avoid the largest proportions of listed anadromous fish that migrate through the action area by limiting in-water work to months that avoid peak migration periods to the best extent practicable. Additionally, most of the effects are not lethal. Construction-related harassment will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or juvenile fish from migrating downstream. Therefore, it is NMFS' opinion that the potential incremental adverse effects of the proposed project does not increase the extinction risk or jeopardize the recovery of the Sacramento River winter-run Chinook salmon ESU, the CV spring-run Chinook salmon ESU, the CCV steelhead DPS, and the Southern DPS of North American green sturgeon.

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 Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon or destroy or adversely modify its designated critical habitat (Table 4).

Table 4. 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?**
Sacramento River winter-run Chinook (*O. tshawytscha*)	No	No	No
CV spring-run Chinook (*O. tshawytscha*)	No	No	No
CCV steelhead (*O. mykiss*)	Yes	No	No
sDPS green sturgeon (*A. medirostris*)	Yes	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

NMFS anticipates incidental take of adult CCV steelhead, and subadult North American green sturgeon from impacts directly related to sedimentation and turbidity, pile driving and impairment of essential behavior patterns as a result of these activities, potential fish entrainment, and the possibility of deleterious materials entering the waterway at the project construction site. The incidental take is expected to be in the form of harm, harassment, or mortality of CCV steelhead and North American green sturgeon resulting from the installation and removal of temporary and permanent piles during bridge construction. Incidental take is expected to occur for any in-water work window seasons when adult CCV steelhead, and subadult North American green sturgeon individuals could potentially be in the action area.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual CCV steelhead and North American green sturgeon because of the variability and uncertainty associated with the population size of the species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the ecological surrogates that will lead to the non-lethal and lethal estimates of take. Ecological surrogates are project elements that are expected to result in take and are somewhat predictable and/or measurable. Ecological surrogates can be monitored to approximate the level of take that occurs.

1) Pile Driving and Acoustic Impacts

The proposed project anticipates installation of all of the steel piles for temporary and permanent piles to be driven by an impact hammer (Table 2 and Table 3). Pile driving with an impact hammer will occur during daylight hours and last up to 8 hours per day, but will likely not be continuous throughout the entire working day. The project will use a variety of steel and CISS piles as described in section 1.3 Proposed Action. All piles will be driven during the in-water pile driving work window, for a maximum of 220 days total, between July 15 and October 15 for the Mokelumne River Bridges site and between July 1 and October 31 for the Paintersville Bridge site.

Pile driving with an impact hammer is expected to cause incidental take in the form of injury and mortality to salmonids and sturgeon through exposure to temporary high noise levels or sustained exposure to lower sound levels (> 206 dB peak or 183 or 187 dB SEL) within the water column during the installation of the steel or CISS piles. The number of listed fish that may be incidentally taken during activities is expected to be small, due to the proposed work window. NMFS will use the area of sound pressure wave impacts extending into the water column from each pile, and the time period for pile driving as a surrogate for number of fish. Based on the acoustic effects analysis (Table 2 and Table 3), peak sound pressures are estimated to be above the thresholds for injury and/or mortality of listed fish within 4 to 86 meters (13.1 to 282.1 feet) of the pile driving depending on the size of piles used and the use of sound attenuation techniques. Cumulative sound exposure levels are expected to exceed the 187 and 183 dB threshold for physical injury for fish greater than 2 grams and less than 2 grams, respectively, within 251 to 10,000 meters (823.5 to 32,808.4 feet) of the pile depending on the size of piles used and the use of sound attenuation techniques (Table 2 and Table 3). Non-injurious behavioral effects are expected to occur within 1,359 to 46,416 meters (4,458.7 to 152,283.5 feet) of the pile depending on the size of pile used and the use of sound attenuation techniques (Table 2 and Table 3). If Caltrans' monitoring indicates that sound levels greater than 206 dB peak, 187 dB or 183 dB cumulative SEL, or 150 dB RMS extend beyond the distances expected for the pile size and attenuation type, the amount of incidental take may be exceeded. 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.

2) Increased Sedimentation and Turbidity

The analysis of the effects of the proposed project anticipates that the turbidity levels produced by installation and removal of piles will not exceed those permitted under the project WPCP and that if turbidity levels approach or exceed the acceptable criteria established by the CVRWQCB, construction activities will be halted until turbidity levels return to within acceptable levels. 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.

3) Construction-related Effects

Incidental take may occur from construction-related effects in the form of injury or death of listed species. Additionally, take in the form of harassment may occur as a result of displacement due to construction operations. Disruption of habitat utilization may result in increased predation risk, decreased feeding, and increased competition. The behavioral modifications that are expected to result from disruption of habitat use are the ecological surrogates for take. There is not a stronger ecological surrogate based on the information available at this time. It is not possible to quantify the exact numbers of individuals that may be affected.

Fish may become entrained in the new steel or CISS piles and may be injured or killed if the piles are dewatered. If Caltrans opts to use 18-inch piles for the temporary trestle, the footprint of the new and temporary piles will be 97.45 square meters. If Caltrans uses 20-inch piles the footprint of the new and temporary piles will be 106.69 square meters. 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.

4) Contaminants and Pollution-related Effects

The analysis of the effects of the proposed project anticipates that levels of pollutants and contaminants will not exceed those permitted under the project WPCP and that if levels approach or exceed the acceptable criteria established by the CVRWQCB, construction activities will be halted until pollution levels return to within acceptable levels. 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 in the sections 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 expected to be exceeded, formal consultation must be reinitiated (50 CFR § 402.16(a)).

2.8.2 Effect of the Take

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 Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and North American green sturgeon or destruction or adverse modification of designated critical habitat for listed fish species.

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. Measures shall be taken to minimize sedimentation events and turbidity plumes in the action area and their direct and indirect effects to listed species and their critical habitat.

2. Measures shall be taken to reduce the potential sound impacts to listed species.

3. Measures shall be taken to minimize pollution or contamination effects to listed species and their critical habitat. Caltrans will enact their emergency spill plan if a spill occurs.

4. Prepare and provide NMFS with a plan and a report describing how listed species in the action area would be protected and/or monitored and to document the observed effects of the action on listed species and critical habitat PBFs in the action area.

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. BMPs shall be implemented to prevent sediment incursion into the active channel.
   b. Water discharged into the Sacramento and Mokelumne Rivers during construction will be filtered with a filter bag, diverted to a settling tank or infiltration area, and/or treated in a manner to ensure that discharges conform to the water quality requirements of the waste discharge permit.
   c. Turbidity and settable solids shall be monitored according to water quality permits. If acceptable limits are exceeded, work shall be suspended until acceptable measured levels are achieved.

2. The following terms and conditions implement reasonable and prudent measure 2:
   a. Noise attenuation methods, such as a bubble curtain, will be used.
   b. Pile-driving will not be conducted at night when migration is most prevalent.

3. The following terms and conditions implement reasonable and prudent measure 3:
   a. Equipment used for the project shall be thoroughly inspected off-site for drips or leaks.
   b. To the extent practicable, equipment will be serviced with petroleum or other contaminant sources off-site.
   c. Equipment used for the project shall be thoroughly cleaned off-site to prevent introduction of contaminants.

4. The following terms and conditions implement reasonable and prudent measure 4:
   a. Caltrans shall provide a report of project activities to NMFS by December 31 of each construction year.
   b. The report shall include project schedules, project completions, and details regarding project implementation for each given year
   c. This report shall include a summary description of in-water construction activities, avoidance and minimization measures taken, and any observed take incidents.

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 provide a NMFS-approved Worker Environmental Awareness Training Program for construction personnel to be conducted by a NMFS-approved biologist for all construction workers prior to the commencement of construction activities. The program shall provide workers with information on their responsibilities with regard to federally-listed fish, their critical habitat, an overview of the life-history of all the species, information on take prohibitions, protections under the ESA, and an explanation of terms and conditions identified in this BO. Written documentation of the training must be submitted to NMFS within 30 days of the completion of training. Completion of this training is consistent with agency requirements set forth in section 7(a)(1).

(2) Caltrans should 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 and Mokelumne River Basins. Implementation of future restoration projects is consistent with agency requirements set forth in section 7(a)(1).

2.10 Reinitiation of Consultation

This concludes formal consultation for the Bridge Seismic Retrofit 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 BO, (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 BO, 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 has determined that the proposed action is not likely to adversely affect Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, or 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 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 2014) 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) thermal refugia.

3.2 Adverse Effects on Essential Fish Habitat

Effects to the HAPCs listed in section 3.1 are discussed in context of effects to critical habitat PBFs as designated under the ESA in section 2.4.2. A list of adverse effects to EFH HAPCs is included in this EFH consultation. Affected HAPCs are indicated by number corresponding to the list in section 3.1:

<u>Pile Driving</u>

- Permanent loss of habitat, due to new CISS piles (1)

<u>Sedimentation and Turbidity</u>

- Reduced habitat complexity (1)
- Reduced size and connectivity of spawning patches (1)
- Increased scouring (1)
- Degraded water quality (1, 2)
- Reduction in aquatic macroinvertebrate production (1)

Contaminants and Pollution-related Effects

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

De-watering of Piles and/or Attenuation Casing

- Degraded water quality (1, 2)
- Temporary loss of habitat (1, 2)

3.3 Essential Fish Habitat Conservation Recommendations

The following are EFH conservation recommendations for the proposed project:

(1) Caltrans should provide a NMFS-approved Worker Environmental Awareness Training Program for construction personnel to be conducted by a NMFS-approved biologist for all construction workers prior to the commencement of construction activities. The program shall provide workers with information on their responsibilities with regard to federally-listed fish, their critical habitat, an overview of the life-history of all the species, information on take prohibitions, protections under the ESA, and an explanation of terms and conditions identified in this BO. Written documentation of the training must be submitted to NMFS within 30 days of the completion of training. HAPCs that would benefit from implementation of this training include (1) complex channels and floodplain habitats and (2) thermal refugia.

(2) Caltrans should 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 and Mokelumne River Basins. HAPCs that would benefit from implementation of restoration projects include (1) complex channels and floodplain habitats and (2) thermal refugia.

Fully implementing the EFH conservation recommendations above would protect EFH for Pacific coast salmon by avoiding or minimizing the adverse effects described in section 3.2.

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 EFH conservation recommendations. 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 post interpretive signs within the action area describing the presence of listed fish and/or critical habitat as well as highlighting their ecological and cultural value.

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 BO addresses these DQA components, documents compliance with the DQA, and certifies that this BO 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 BO are the California Department of Transportation. Other interested users could include: Sacramento County, San Joaquin County, community of Paintersville, U.S. Coast Guard, U.S. Fish and Wildlife Service, and California Department of Fish and Wildlife. Individual copies of this BO were provided to the California Department of Transportation. This BO 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 BO and EFH consultation contain more background on information sources and quality.

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

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

6. REFERENCES

A. Literature and Federal Register Notices Cited

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.

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.

Anderson, N. H. and J. R. Sedell. 1979. Detritus Processing by Macroinvertebrates in Stream Ecosystems. Annual Review of Entomology 24(1):351-377.

Arkoosh, M. and T. Collier. 2002. Ecological Risk Assessment Paradigm for Salmon: Analyzing Immune Function to Evaluate Risk. Human and Ecological Risk Assessment 8(2):265-276.

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.

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

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.

Benson, R. L., S. Turo, and B. W. McCovey. 2007. 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.

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 Fish and Game. 1998. A Status Review of the Spring-Run Chinook Salmon [Oncorhynchus Tshawytscha] in the Sacramento River Drainage. Candidate Species Status Report 98-01. California Department of Fish and Game, 394 pp.

California Department of Fish and Game. 2007. California Steelhead Fishing Report-Restoration Card. California Department of Fish and Game.

California Department of Transportation. 2010. Standard Specifications. State of California Department of Transportation.

California Department of Transportation. 2012. Compendium of Pile Driving Sound Data. State of California Department of Transportation.

California Department of Transportation. 2016. Biological Assessment (National Oceanic and Atmospheric Administration National Marine Fisheries Service): California Department of Transportation's Bridge Seismic Retrofit Project 03-3f090 Mokelumne River Bridges I-5 in Sacramento County, Paintersville Bridge SR-160 in Sacramento County, and North Sacramento Undercrossing SR-160 in the City of Sacramento State of California Department of Transportation.

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

Deng, X., J. P. Van Eenennaam, and S. I. Doroshov. 2002. Comparison of Early Life Stages and Growth of Green and White Sturgeon. Pages 237-248 *in* American Fisheries Society Symposium.

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

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

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

Dimacali, R. L. 2013. A Modeling Study of Changes in the Sacramento River Winter-Run Chinook Salmon Population Due to Climate Change. 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 Streams. Wiley Online Library.

Emmett, R. L., S. L. Stone, S. A. Hinton, and M. E. Monaco. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries Volume Ii: Species Life History Summaries. NOAA/NOS Strategic Environmental Assessments Division, ELMR Report Number 8, 329 pp.

Erickson, D., J. North, J. 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. 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:1675-1682.

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

Foster, E., M. Fitzpatrick, G. Feist, C. Schreck, and J. Yates. 2001a. Gonad Organochlorine Concentrations and Plasma Steroid Levels in White Sturgeon (Acipenser Transmontanus) from the Columbia River, USA. Bulletin of environmental contamination and toxicology 67(2):239-245.

Foster, E., M. Fitzpatrick, G. Feist, C. Schreck, J. Yates, J. Spitsbergen, and J. Heidel. 2001b. Plasma Androgen Correlation, Erod Induction, Reduced Condition Factor, and the Occurrence of Organochlorine Pollutants in Reproductively Immature White Sturgeon (Acipenser Transmontanus) from the Columbia River, USA. Archives of Environmental Contamination and Toxicology 41(2):182-191.

Gaspin, J. B. 1975. Experimental Investigations of the Effects of Underwater Explosions on Swimbladder Fish. I. 1973 Chesapeake Bay Tests. DTIC Document.

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(3):604-609.

Gisiner, R. C. 1998. Proceedings: Workshop on the Effects of Anthropogenic Noise in the Marine Environment, 10-12 February 1998. United States, Office of Naval Research.

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 Fisheries and Aquatic Sciences 50(2):241-246.

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

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

Hastings, M. C. 1995. Physical Effects of Noise on Fishes. INTER-NOISE and NOISE-CON Congress and Conference Proceedings 1995(2):979-984.

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

Intergovernmental Panel on Climate Change. 2007. Summary for Policymakers: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, 18 pp.

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, and 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(5):517-538.

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

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. J. 2008. Overbite Clams, Corbula Amurensis, Defecated Alive by White Sturgeon, Acipenser Transmontanus. CALIFORNIA FISH AND GAME EDITOR 1416 NINTH ST, SACRAMENTO, CA 95814 USA.

Kruse, G. and D. Scarnecchia. 2002. Assessment of Bioaccumulated Metal and Organochlorine Compounds in Relation to Physiological Biomarkers in Kootenai River White Sturgeon. Journal of Applied Ichthyology 18(4-6):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 Synergistics Toxicity of Pesticides Mixtures: Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives 117(3):348-353.

Lindley, S. 2008. California Salmon in a Changing Climate.

Lindley, S. T., R. S. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESUs in California's Central Valley Basin. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-360.

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.

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(1):51-64.

Liu, Z. and B. Huang. 2000. Cause of Tropical Pacific Warming Trend. Geophysical research letters 27(13):1935-1938.

Martin, C. D., P. D. Gaines, and R. R. Johnson. 2001. Estimating the Abundance of Sacramento River Juvenile Winter Chinook Salmon with Comparisons to Adult Escapement. U.S. Fish and Wildlife Service.

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

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

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

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

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

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

McReynolds, T. R., C. E. Garman, P. D. Ward, and S. L. Plemons. 2007. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncoryhnchus Tshawytscha*, Life History Investigation 2005-2006. California Department of Fish and Game, Administrative Report No. 2007-2.

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. 2013. 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 96(2-3):257-271.

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 Oncorhynchus Tshawytscha in a Sacramento River Tributary after Cessation of Migration. Environmental Biology of Fishes 96(2-3):405-417.

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

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish Species of Special Concern in California, Second Edition. California Department of Fish and Game.

Muir, W. D., G. T. McCabe Jr, S. A. Hinton, and M. J. Parsley. 2000. Diet of First-Feeding Larval and Young-of-the-Year White Sturgeon in the Lower Columbia River.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California., Report No. NMFSNWFSC-35. NOAA Tech. Memo. U.S. Department of Commerce.

National Marine Fisheries Service. 1993. Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon. Federal Register 58(114):33212-33219.

National Marine Fisheries Service. 2005a. Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. Federal Register 70(170):52488-56627.

National Marine Fisheries Service. 2005b. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(D) Protective Regulations for Threatened Salmonid ESUs. Federal Register 70(123):37160-37204.

National Marine Fisheries Service. 2006a. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Populatoin Segments of West Coast Steelhead; Final Rule. Federal Register 71(3):834-861.

National Marine Fisheries Service. 2006b. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 71(71):67.

National Marine Fisheries Service. 2009a. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce.

National Marine Fisheries Service. 2009b. Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 74(195):52300.

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

National Marine Fisheries Service. 2011b. 5-Year Review: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon. U.S. Department of Commerce, 38 pp.

National Marine Fisheries Service. 2011c. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species October 1, 2008–September 30, 2010.

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

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

National Marine Fisheries Service. 2016a. Endangered and Threatened Species; 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon. Federal Register 81(102):33468.

National Marine Fisheries Service. 2016b. Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat. Federal Register 81(28):7414.

Nguyen, R. M. and C. E. Crocker. 2007. 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(4):1044-1055.

Noakes, D., R. Beamish, L. Klyashtorin, and G. McFarlane. 1998. On the Coherence of Salmon Abundance Trends and Environmental Factors. North Pacific Anadromous Fish Commission Bulletin 1:454-463.

Pacific Fishery Management Council and National Marine Fisheries Service. 2014. Environmental Assessment and Regulatory Impact Review Pacific Coast Salmon Plan Amendment 18: Incorporating Revisions to Pacific Salmon Essential Fish Habitat.

Paerl, H. W., N. S. Hall, and E. S. Calandrino. 2011. Controlling Harmful Cyanobacterial Blooms in a World Experiencing Anthropogenic and Climatic-Induced Change. Science of the Total Environment 409(10):1739-1745.

Paul, M. J. and J. L. Meyer. 2008. Streams in the Urban Landscape. Pages 207-231 *in* Urban Ecology. Springer.

Petersen, J. H. and J. F. Kitchell. 2001. Climate Regimes and Water Temperature Changes in the Columbia River: Bioenergetic Implications for Predators of Juvenile Salmon. Canadian Journal of Fisheries and Aquatic Sciences 58(9):1831-1841.

Popper, A. N., T. J. Carlson, A. D. Hawkins, B. L. Southall, and R. L. Gentry. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper. Report to the Fisheries Hydroacoustic Working Group, California Department of Transportation, USA, 15pp.

Popper, A. N. and M. C. Hastings. 2009. The Effects of Human-Generated Sound on Fish. Integrative Zoology 4(1):43-52.

Poytress, W. R., J. J. Gruber, J. P. Van Eenennaam, and M. Gard. 2015. Spatial and Temporal Distribution of Spawning Events and Habitat Characteristics of Sacramento River Green Sturgeon. Transactions of the American Fisheries Society 144(6):1129-1142.

Pusey, B. J. and 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. Fish Bulletin - Ecological Studies of the Sacramento-San Joaquin Delta. Part II: Fishes of the Delta(136).

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. Pacific Grove, CA.

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

Schaffter, R. 1980. Fish Occurrence, Size, and Distribution in the Sacramento River near Hood, California During 1973 and 1974. California Department of Fish and Game, Administrative Report No. 80-3.

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 Behaviour: Integrating Behavioural and Physiological Indicators of Toxicity. Aquatic Toxicology 68(4):369-392.

Sigler, J. W., T. Bjornn, and F. H. Everest. 1984. Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon. Transactions of the American Fisheries Society 113(2):142-150.

Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic Mapping of Pelagic Fish Distribution and Abundance in Relation to a Seismic Shooting Area Off the Norwegian West Coast. Fisheries Research 67(2):143-150.

Snider, B. and R. G. Titus. 2000. Timing, Composition and Abundance of Juvenile Anadromous Salmonid Emigration in the Sacramento River near Knights Landing October 1998–September 1999. California Department of Fish and Game, Stream Evaluation Program Technical Report No. 00-6.

Stachowicz, J. J., H. Fried, R. W. Osman, and R. B. Whitlatch. 2002. Biodiversity, Invasion Resistance, and Marine Ecosystem Function: Reconciling Pattern and Process. Ecology 83(9):2575-2590.

Stewart, I. T., D. R. Cayan, and M. D. Dettinger. 2005. Changes toward Earlier Streamflow Timing across Western North America. Journal of climate 18(8):1136-1155.

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

Thompson, L. C., M. I. Escobar, C. M. Mosser, D. R. Purkey, D. Yates, and P. B. Moyle. 2011. Water Management Adaptations to Prevent Loss of Spring-Run Chinook Salmon in California under Climate Change. Journal of Water Resources Planning and Management 138(5):465-478.

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.

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 Eenennaam, J. P., M. A. Webb, X. Deng, S. I. Doroshov, R. B. Mayfield, J. J. Cech Jr, D. C. Hillemeier, and T. E. Willson. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transactions of the American Fisheries Society 130(1):159-165.

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

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

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

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.

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.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2003. Butte and Big Chico Creeks Spring-Run Chinook Salmon, Oncoryhnchus Tshawytscha Life History Investigation: 2001-2002. California Department of Fish and Game, 59 pp.

Wardle, C., T. Carter, G. Urquhart, A. Johnstone, A. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of Seismic Air Guns on Marine Fish. Continental Shelf Research 21(8):1005-1027.

Waters, T. F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7.

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

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

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.

Wood, P. J. and P. D. Armitage. 1997. Biological Effects of Fine Sediment in the Lotic Environment. Environmental Management 21(2):203-217.

Workman, M. 2016. Fish Presence in the Mokelumne River. pers. comm. N. McIntosh. August 25, 2016.

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.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:485-521.