Appendix C: Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation from the National Marine Fisheries Service

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

RECEIVED
JUL 21 2016
Contra Costa Water District
Planning Department

JUL 7 2016

Refer to NMFS No: WCR-2016-4082

Mr. David Hyatt
Resource Management Division Chief
U.S. Bureau of Reclamation
South-central California Area Office
Fresno, California 93721-1813

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Cypress Preserve Project (15-049; SPK-2014-01048)

Dear Mr. Hyatt:

Thank you for your letter of January 21, 2016, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*) for the East Cypress Preserve Project (Project). The U.S. Bureau of Reclamation (Reclamation) proposes the inclusion of the Project into Contra Costa Water District's (CCWD's) Service Area for the Central Valley Project (CVP). The Project is located within the City of Oakley in Contra Costa County, California.

NMFS analyzed the potential effects of the Project on federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and the designated critical habitats of California Central Valley steelhead and Southern DPS of North American green sturgeon in accordance with section 7 of the ESA. This letter also transmits the results of the Essential Fish Habitat (EFH) consultation under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*).

In the enclosed biological opinion, NMFS concludes that the Project is not likely to jeopardize the continued existence of the above-listed species and that the action is not likely to adversely affect Sacramento River winter-run and Central Valley spring-run Chinook salmon. NMFS also concluded the Project is not likely to result in the destruction or adverse modification of critical habitat for California Central Valley steelhead and southern DPS green sturgeon. However, NMFS anticipates that take will occur in the form of death, injury, or harm to the species and temporary changes to the habitat during and after the construction phase. An incidental take statement with non-discretionary terms and conditions is included.

Regarding EFH, NMFS has reviewed the proposed Project for potential effects and determined that the Project would adversely affect EFH for various federally-managed fish species under the Pacific Salmon, Coastal Pelagic, and Pacific Groundfish Fishery Management Plans. Therefore, EFH Conservation Recommendations are included in this biological opinion.

Please be advised that regulations (50 CFR 600.920) to implement the EFH provisions of the MSA requires Reclamation to provide a written response to this letter within 30 days of its receipt and prior to start of the action. The response must include a description of measures adopted by Reclamation for avoiding, minimizing, or mitigating the impact of the activity. In the case of a response that is inconsistent with NMFS recommendations, Reclamation must explain its reasons for not following the recommendations, including the scientific justification for any disagreements at least 10 days prior to final approval of the action.

This biological opinion is based on information provided by Reclamation and its consultant (Tenera Environmental), and a literature review completed by NMFS staff. A complete administrative record of this consultation is on file at the NMFS California Central Valley Office in Sacramento.

Please contact Bruce Oppenheim at (916) 930-3603, or via e-mail *bruce.oppenheim@noaa.gov* if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

for William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Copy to file: 151422WCR2016-SA00208

Bill Guthrie, U.S. Corps of Engineers, 1325 J Street, Room 1350, Sacramento, CA 95814-2922

Elizabeth Kiteck, U.S. Bureau of Reclamation, Central Valley Office, 3310 El Camino Ave, Suite 300, Sacramento, CA 95821

Armin Halston, U.S. Fish and Wildlife Service, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814-4700

Mark Seedall, Contra Costa Water District, P.O. Box H20, Concord, CA 94524-2099

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

Cypress Preserve Project (15-049, SPK-2014-01048)

NMFS Consultation Number: ARN 151422WCR2016-SA00208

Action Agency: U.S. Bureau of Reclamation

Affected Species and NMFS's Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Adversely 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 (*Oncorhynchus tshawytscha*)	Endangered	No	N/A[1]	No	N/A[1]
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	Yes	No	No
Central Valley spring-run Chinook (*O. tshawytscha*)	Threatened	No	N/A[1]	No	N/A[1]
North American green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No

[1] N/A – Not Applicable

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

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

Issued By: for William W. Stelle, Jr.
Regional Administrator

Date: JUL 7 2016

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LIST OF ACRONYMS

BA	Biological Assessment
BMPs	Best Management Practices
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game (before 2013)
CDFW	California Department of Fish and Wildlife (after 2013)
cfs	cubic feet per second
cm	centimeters
CRR	cohort return rate
CWT	coded wire tag
Corps	U.S. Army Corps of Engineers
CVP	Central Valley Project
cSEL	cumulative sound exposure level
dB	decibel
DPS	distinct population segment
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FL	Fork Length
FMP	Fishery Management Plan
FWS	U.S. Fish and Wildlife Service
m	meter
mm	millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	mean sea level
NMFS	National Marine Fisheries Service
NTUs	nephelometric turbidity units
PAHs	polycyclic aromatic hydrocarbons
PBF	physical or biological feature of critical habitat
PCBs	polychlorinated biphenyls
PFMC	Pacific Fisheries Management Council
ppt	parts per thousand (unit)
Reclamation	U.S. Bureau of Reclamation
RMS	root square mean
RST	rotary screw traps
RWQCB	Regional Water Quality Control Board
SEL	sound exposure level
USFWS	U.S. Fish and Wildlife Service
µg/l	micrograms per liter (unit)
µg/kg	micrograms per kilogram (unit)
VSP	viable salmonid population

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (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) as amended (16 U.S.C. 1801 *et seq.*) and implementing regulations at 50 CFR 600.

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

1.2 Consultation History

- A proposed project description was sent to NMFS by the U.S. Bureau of Reclamation (Reclamation) for review and comment in late September 2015.
- On October 28, 2015, a site visit to Rock Slough and the proposed residential development was held with Reclamation, NMFS, the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), Tenera Environmental (Tenera), and the applicant (ACD-TI Oakley, LLC). The anticipated effects and permitting requirements were discussed.
- On December 7, 2015, Reclamation was designated as the lead Federal agency by the U.S. Army Corps of Engineers (Corps).
- On January 25, 2016, NMFS received a request for ESA concurrence and a biological assessment (BA) dated January 21 from Reclamation (Reclamation 2016).
- On February 2, 2016, Reclamation sent NMFS missing information (Table A-4, containing information on the number of adult Chinook salmon recovered from the debris pits at the Rock Slough Fish Screen) from the BA.
- On February 9, 2016, NMFS responded to Reclamation's request with a letter of non-concurrence, and concluded that it had received all the information necessary to initiate formal consultation. Formal consultation is considered to have begun on February 2, 2016. This is the date NMFS received all of the information necessary to start consultation.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). The Cypress Preserve Project (formerly known as the East Cypress Corridor Project) consists of five properties under option for purchase by ACD-TI Oakley, LLC (the Project applicant). The current proposal is a component of the 2,546-acre mixed-use residential development approved by the City of Oakley in 2006. The City of Oakley, after a legal challenge, recertified the Environmental Impact Report on March 10, 2009, and reapproved the East Cypress Corridor Specific Plan (General Plan amendment).

The Federal action is the inclusion of 1,246.6 acres of land that comprise the Cypress Preserve Project (Project) into the Contra Costa Water District's (CCWD's) service area[1] for receipt of Central Valley Project (CVP) water supplies. On December 7, 2015, the Corps designated Reclamation as the lead Federal agency for purposes of compliance with section 7 of the Endangered Species Act (ESA). The Corps' proposed actions are the approval of a standard individual permit pursuant to section 404 of the Clean Water Act, and issuance of a permit under section 10 of the Rivers and Harbors Act of 1899.

The Project includes the development of up to 310.8 acres of residential uses (2,400 residential units), 24.7 acres of commercial use, 19.8 acres of public schools, 24.8 acres of parks, and 3.6 acres of common area; 455.8 acres of open space/easements/lakes/preserves, 22.6 acres of gas well sites and a water tank site, 133.9 acres of wetlands/dunes, 76.3 acres of flood control levees (23,182 feet), and 174.3 acres of roads.

The Project includes the construction of infrastructure including streets, water lines, sewer lines, regional sewer lift station, regional water tanks and associated pumping facilities, landscaped areas, stormwater detention basins, and stormwater pumps. The Project also includes construction of the bridge over Rock Slough, which is necessary to provide southern ingress and egress for the East Cypress Road corridor and Bethel Island, as well as for public safety access for police, fire and medical responders in the event of on-site emergencies. The Project does not include the construction of the connector road south of the bridge to Delta Road; this road will be built within an existing right-of-way (ROW) and will be built and funded by the Contra Costa County Transportation Authority.

Two components of the Project have the potential to affect listed fish species, EFH, and EFH-managed species: construction of the Rock Slough Bridge and the periodic release of treated stormwater. These Project components are described in the following subsections.

A. Project Activities

1. <u>Inclusion of 1,246.6 acres into the CCWD service area for CVP water supply</u>

Reclamation proposes the following, all of which would require Reclamation/CCWD to issue an encroachment permit/license/easement:

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[1] CCWD receives a portion of its water supply from Federal Central Valley Project through the Delta.

(1) The Cypress Road Expansion, which includes a utility corridor for gas, power, water, sewer, cable, phone, stormwater, and utilities. An estimated roadway expansion of 150 feet northwest of the existing Cypress Road would require a crossing of Reclamation's property. This area may also include levee work;
(2) a levee encroachment onto Reclamation ROW south of Cypress Road. The distance of the encroachment is expected to be approximately 1,000 feet;
(3) a levee abutment/connection northwest of the setback levee for the Rock Slough Fish Screen. The existing Rock Slough Fish Screen setback levee would be used for the East Cypress Corridor perimeter levee; and
(4) a levee abutment/connection southeast of the setback levee for the Rock Slough Fish Screen.

Reclamation would also relocate the Rock Slough Fish Screen log boom to the east side of the proposed bridge across Rock Slough. Reclamation and CCWD would enter into a modified Reclamation District (RD799) access agreement to reflect portions of the East Cypress Corridor Perimeter Levee that are within the Reclamation ROW. The area along the Contra Costa Canal which is owned by Reclamation overlaps with the Project's southern boundary (Figure 1).

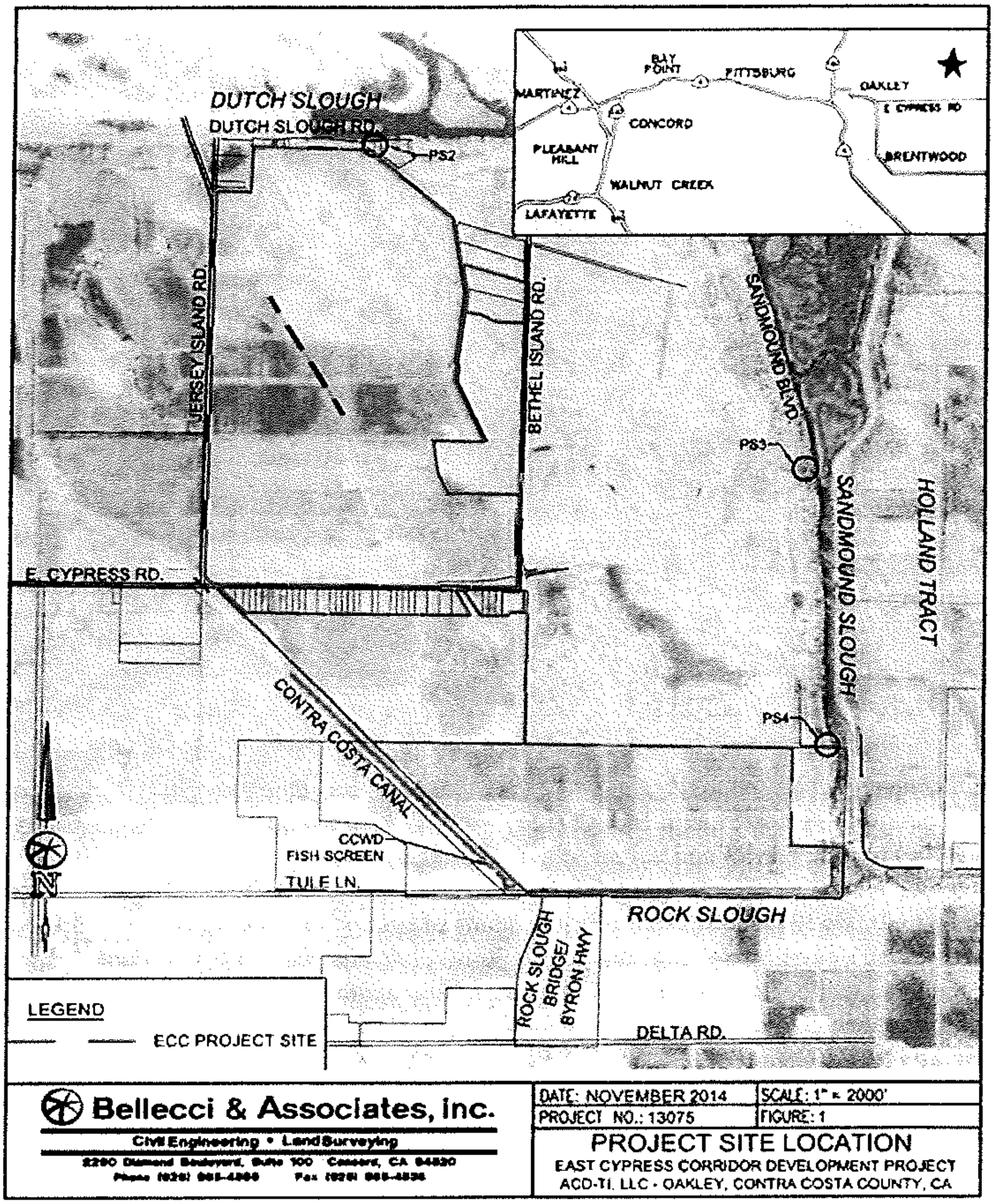

Figure 1. Vicinity map showing Contra Costa Canal, Project boundaries, pump stations PS2, PS3, PS4, and Rock Slough Bridge location. (Source: Reclamation 2016)

2. Rock Slough Bridge Construction

Located immediately south and east of the CCWD fish screen in Rock Slough, the proposed bridge over Rock Slough will provide a second vehicle access point to the Project Area and to Bethel Island residents. The bridge is a required improvement in the City of Oakley's East Cypress Corridor Specific Plan and will relieve traffic congestion on East Cypress Road (located in middle of proposed development) as development of the Project and Bethel Island proceeds. The proposed new bridge will span Rock Slough and connect with Byron Highway to the south as shown in Figure 2.

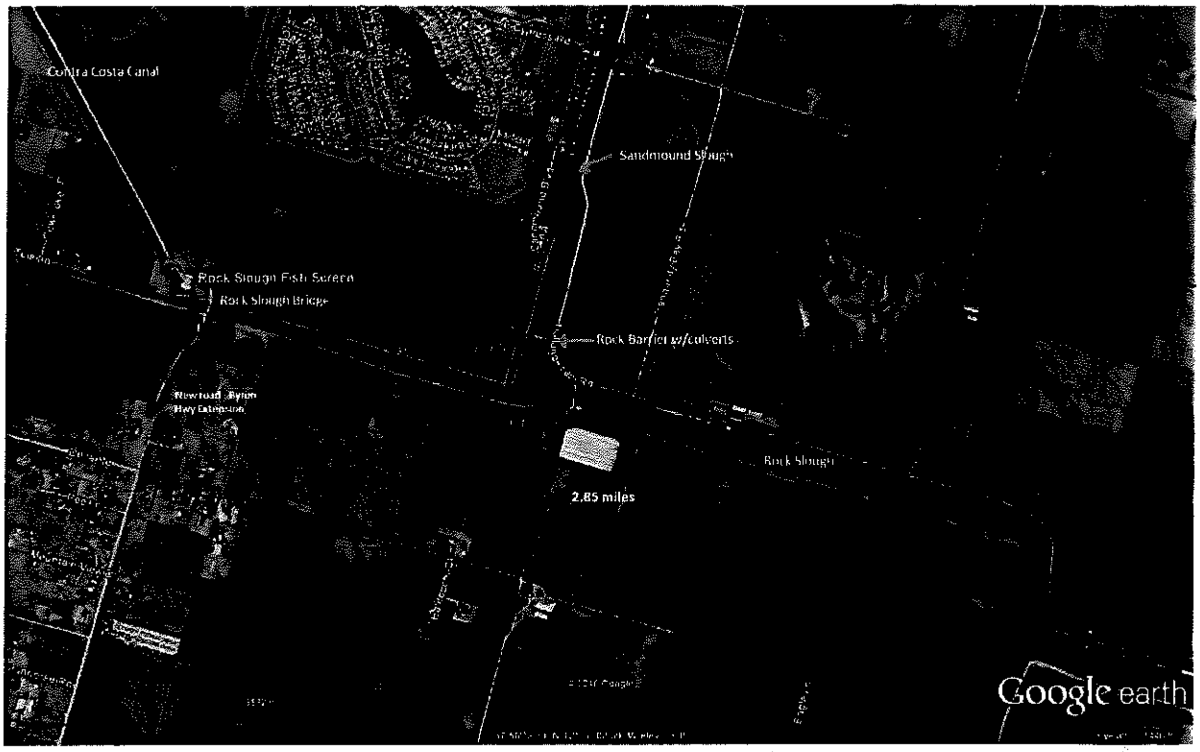

Figure 2. Location of Rock Slough Bridge (red), CCWD Fish Screen, Contra Costa Canal, and distances (blue) to rock barrier and extent of sound impacts.

The bridge structure will be comprised of three spans of precast and pre-stressed concrete voided slab girders sitting on reinforced concrete two-column piers and seat-type abutments. The total length of the span will be approximately 220 feet and the width will be approximately 56 feet. The length of the bridge over the slough will be approximately 210 feet (Figure 3); a total of 12,320 square feet (0.028 acre) of structure over Rock Slough will result from construction of the bridge. The bridge will initially provide one lane in each direction, shoulders on both sides, and a sidewalk on both sides. The height of the bridge will be a minimum of 10 feet above mean higher high water (MHHW) to allow for aquatic vegetation mechanical harvesting equipment that may be used in front of the Rock Slough Fish Screen as part of CCWD's aquatic vegetation management program. The Rock Slough Fish Screen is located 240 feet upstream of the Bridge construction (Figure 3). The bridge will not require painting.

Construction of the Rock Slough Bridge involves both in-water and land-based activities. In-water construction activities in Rock Slough will include installing pin piles for pile driving templates and falsework trestle piles to support two temporary work trestles (work platforms), installing permanent cast-in-steel-shell (CISS) piles, removing the pin piles, falsework trestle piles, and temporary work trestles, removing existing rock rip-rap prior to construction of the abutments, and replacing the rock rip-rap after construction of the abutments.

a) Pile Driving Activity

Two temporary work trestles will be constructed on both ends of the bridge to provide working platforms during bridge construction. Prior to construction of the work trestles, twenty-four (24) 14-inch steel pin piles for pile driving templates will be installed using a vibratory hammer; use of an impact hammer is not anticipated (Figure 3). Each work trestle will be supported by six (6) 24-inch steel trestle piles installed in the water and two (2) 24-inch steel trestle piles installed on land, for a total of twelve (12) 24-inch piles installed in the water and four (4) installed on land. The 24-inch steel shell pipes for the construction of the temporary trestles will be imbedded approximately 40 feet and will be installed by vibratory hammer. The work trestles will be 30 feet wide and will extend approximately 50 feet over the water in Rock Slough from each side. The steel trestle piles will initially be driven into the bottom of the slough with a vibratory hammer; it may be necessary to use an impact hammer to drive the final length. Sound generated from driving the temporary piles will be attenuated by installing and operating either a bubble curtain, bubble tree, or some other form of NMFS-approved attenuation device.

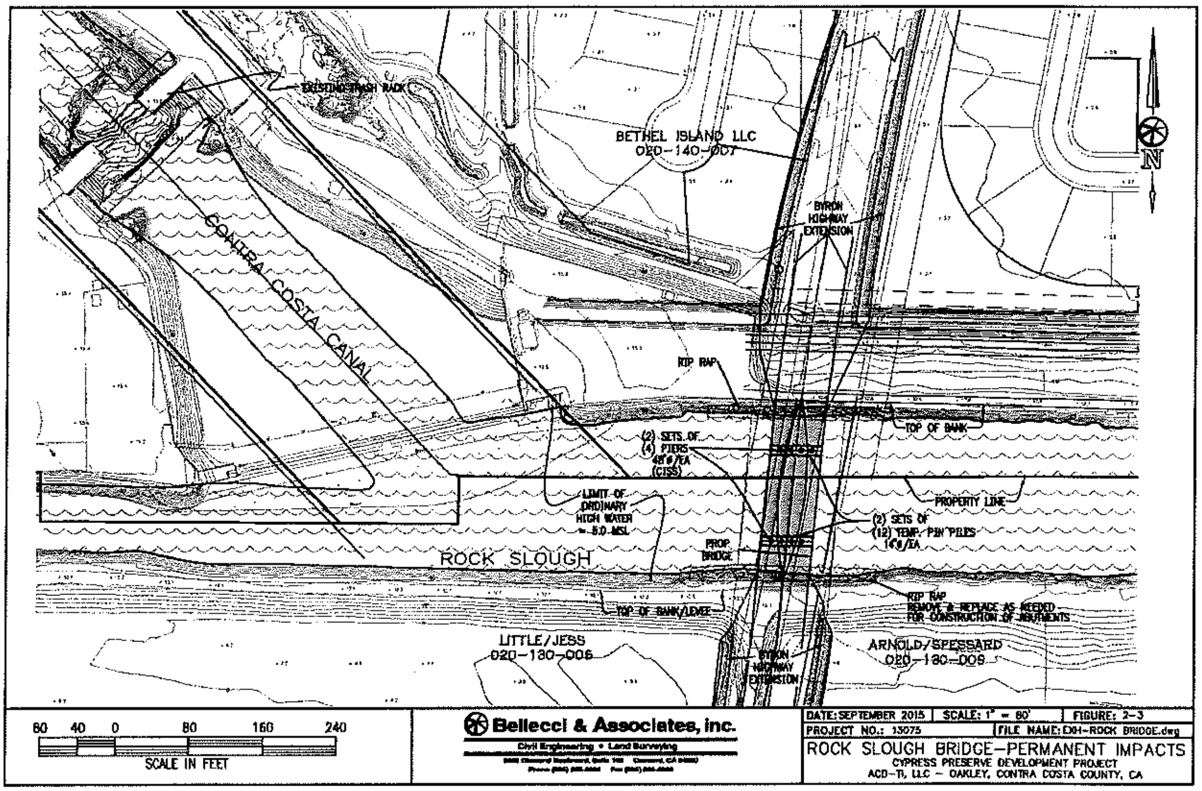

Figure 3. Proposed Rock Slough Bridge showing the crossing location near CCWD's Contra Costa Canal Intake and Fish Screen. Also, location of the 24 temporary 14-inch diameter pin piles and the eight permanent 48-inch diameter CISS piles. (Source: Reclamation 2016)

The permanent bridge piles will require driving four sets (8 total) of 48-inch diameter CISS piles in Rock Slough (Figure 3). The CISS piles consist of a steel shell containing a reinforced concrete core. The CISS piles will initially be driven into the bottom of the slough with a vibratory hammer; it is likely that an impact hammer be used to drive the final length. Based on projects with similar substrate conditions, it is assumed that the CISS permanent piles will be imbedded 60–80 feet with the final length dependent on geotechnical subsoil strength characteristics. The contractor will install the permanent shell for the CISS piles within oversized steel casings. Sound generated from driving the permanent piles will be attenuated by either maintaining a dewatered void within the oversize steel casings or allowing water to fill the space within the oversized steel casings and installing and operating a bubble curtain or bubble trees between the casings and the permanent piles throughout the pile driving operation. During pile installation, noise will be monitored and limited to a predetermined threshold after this consultation.

Abutments will be placed on land at the north end and south ends of the bridge. The abutments will be constructed above the 300-year flood elevation, and will not require any in-water work. The slopes of both sides of Rock Slough have existing rock rip-rap extending from the waters of Rock Slough to the tops of the levee roads. A portion of this existing rip-rap would be temporarily removed to allow construction of the abutments and work trestles. No new rock rip-rap will be required to armor the abutments in order to prevent scour and erosion.

Generalized construction activities and sequences will likely include the following steps:

1. Conduct fill and grade activities at each end of the new bridge associated with the construction of two temporary construction trestles from which the in-water work will be conducted (in-water work).
2. Use a vibratory hammer to install approximately sixteen 24-inch steel trestle piles (14 in water, 2 on land) to support two temporary work trestles, and twenty four 14-inch steel pin piles for pile driving templates. Each work trestle would be 30 feet wide and extend approximately 55 feet into Rock Slough from each side.
3. Drive eight (2 sets of 4 each) 48-inch diameter CISS piles at approximately 55 feet from each abutment using a vibratory hammer and an impact hammer if necessary (in-water work).
4. Form and pour concrete pile bent caps at each set of pile locations (land-based work).
5. Remove concrete forms and place precast concrete bridge support girders (land-based work).
6. Form and pour concrete bridge deck (land-based work).
7. Remove bridge deck form work (land-based work).
8. Remove the temporary trestle piles, temporary pin piles, and temporary work trestles (in-water work),
9. Drive sheet piles to enable abutment construction within slough limits yet outside and above water limits (land-based).
10. Excavate and form/reinforce/pour abutments (land-based work).
11. Complete placement of scour/erosion measures and final grading at abutments (land-based work).

It is anticipated the in-water work associated with construction and removal of the temporary work trestles and installing the permanent bridge piles can be completed within one season's work window (August 1–October 15). Construction is scheduled to begin in 2016 depending on permits. The in-water work will include pile driving (vibratory) for temporary work trestles, CISS pile driving (vibratory first and impact only if necessary) and placement, and removal of the temporary work trestles and templates. It will take approximately 3 weeks to construct the trestles, including driving the in-water 14-inch steel pin piles and the 24-inch steel trestle piles. The length of time to vibrate in each CISS pile is estimated at 4 hours per pile. If an impact hammer must be used to drive or proof the piles, it is estimated to take 2 hours per pile. Driving of the eight CISS 48-inch piles will be scheduled to occur over 4 days.

Replacement of the existing rip-rap rock slope protection may need to occur in the following year's work window after completion of the concrete bridge. The following equipment will be used to construct the Rock Slough Bridge: crawler cranes equipped with vibratory pile driving hammers, hydraulic power packs, impact hammers, clam shells, excavators, drilling rigs, loaders, haul trucks, concrete placing booms, and concrete ready-mix trucks.

B. Interrelated and Interdependent Actions

When considering the direct and indirect effects of an action on a species or critical habitat, an action agency must also include the potential effects of other activities that are interrelated or interdependent with that action. "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). Activities that are considered interrelated or interdependent to this Project would include the future residential and commercial development inside the action area that would not take place but for the Federal action of inclusion into the CCWD service area and the actions associated with that development (*e.g.*, roads, sewer lines, landscaping, stormwater treatment facilities).

1. Stormwater Retention and Discharge

The Project applicant, ACD-TI Oakley, LLC, has prepared updated hydrologic, hydraulic, and water quality analyses for the Project, which is summarized in an overall Stormwater Control Plan (SCP) for the future development (Reclamation 2016, Appendix C). The current discharge of all surface water runoff within the action area is to Dutch Slough and Sandmound Slough through existing pump stations (PS2 and PS4) that are owned and operated by RD799 (see Figure 1). The existing hydrologic conditions of the Project are described in the SCP. The two pump stations were constructed to handle the runoff that occurs during irrigation of the agricultural land within the Project boundary. While the existing pump stations can accommodate the calculated surface water runoff from the Project, RD799 has plans to upgrade

Pump Stations 2 and 4 to provide service redundancy and modernize their facilities. These upgrades will not involve impacts to aquatic habitat.

The Project's storm drain system will replace the existing network of open drainage ditches that currently collect untreated surface water. All Project-generated runoff is designed to drain to a system of central lakes that are proposed as part of the Project storm drain system. The proposed lakes will provide water quality enhancement features in addition to providing stormwater detention. Surface water runoff from the existing residences along East Cypress Road and

Bethel Island Road (referred to as non-Project areas), will be collected in the Project's comprehensive drainage system, including within the lakes, and pumped over the Project interior levee and discharged into existing RD799 drainage canals.

Stormwater pump stations will move surface water runoff from within the interior of the urban levee to the inter-levee area. The northerly lift station will move surface water runoff from both the non-Project (Bethel Island Road, East Cypress Road, and existing residential areas south of East Cypress Road) and Project areas within the interior levee over the levee to the RD799 drainage canal that flows to Pump Station 2. There will be no levee penetration associated with moving the water over the new levee. The southerly lift station located on the southeastern portion of Project Area will discharge surface water runoff from the Dal Porto South and Bethel Island properties and runoff from the Summer Lake project (existing residential development) over the interior levee to Pump Station 4.

The Project stormwater lake features are significantly downsized, therefore eliminating the need for upgrades to the stormwater system in the sloughs. The capacity of the existing RD799 outfall pipes would be sufficient to handle the Project's treated stormwater (Balance Hydrologics 2015). This design change eliminates the need to construct new facilities in Dutch or Sandmound sloughs and therefore, eliminates the need for mitigation. Upgrades to the existing land-based pumps might be necessary; however, this work would not occur within Dutch Slough or Sandmound Slough and is not anticipated to result in any permanent impacts to jurisdictional waters of the United States. RD799 would continue to maintain and operate the stormwater retention system after the 5 parcels within the proposed Project are developed.

Creation of the on-site retention lakes will be incorporated as part of the SCP. The surface area of the lakes is estimated to be approximately 32 acres. The on-site retention lakes will be of sufficient volume capacity to retard peak stormwater flows by retaining stormwater. Balance Hydrologics (2015) determined that the resultant peak discharge from the lake system will not be greater than the current peak discharge from the irrigated pasture land. Because the lakes will include clay liners to separate them from the shallow ground-water system, loss of water from the lakes through seepage will be extremely small, if it occurs at all (Balance Hydrologics 2015).

However, there will still be substantial losses of water from the lakes due to evaporation, particularly during the hot, dry summer period. Balance Hydrologics (2015) provided preliminary calculations of evaporation rates for the lakes based on the pan evaporation record for Antioch. The calculations show that runoff into the lakes can be expected to equal or exceed evaporation rates over the long term for the months of October–April. Make-up water will be needed to maintain lake water surface elevations during the period from May–September, with the predicted maximum evaporation excess of 8.1 inches in July. This is equivalent to a make-up water demand of roughly 22 acre-feet in the month of July just to replace water lost to evaporation. Other water-quality management considerations in the lakes will likely call for additional make-up water, with the amounts varying by year and season. These make-up demands will be met through augmentation using groundwater from appropriately sited wells; no make-up water will be withdrawn from the Delta. Balance Hydrologics (2015) determined that summer demands could be largely offset, if desired, through the implementation of rainwater harvesting (*e.g.*, passive storage through landscaping design, mulch, permeable pavement, and rain barrels) using the lakes as a central storage component.

C. Proposed Minimization Measures

Design features integrated into the Project to avoid, minimize, or compensate for potential impacts to listed species and designated critical habitats include the following measures:

<u>1. Construction/Deconstruction Pollution Prevention Plan</u>

Prior to construction of the new bridge, the Project applicant's contractor will prepare and implement a Construction/Deconstruction Pollution Prevention Plan. This plan will detail all steps to be taken, including selection of equipment and operational procedures, to ensure that no construction or deconstruction debris is accidentally deposited or remains in the waters of Rock Slough and could pose a threat to special-status fish species and their habitat. This plan will conform to all Corps, Regional Water Quality Control Board (RWQCB), and City of Oakley permit conditions. The plan will include, but is not be limited to:

(1) Training of all personnel engaged in construction/deconstruction activities as to the importance of preventing any materials from entering the water.

(2) Measures to be implemented to prevent foreign materials (*e.g.*, wood scraps, wood preservatives, fuels, lubricating oils, hydraulic fluids, and other chemicals) from entering Rock Slough. This requirement will include, but not be limited to:

   a. Abundant on-site closable trash containers in which all packaging materials and trash can be placed. Frequent removal and replacement of all trash containers will occur to ensure that adequate empty containers are on site at all times.
   b. Provision of labeled and separate containers for different types of recyclable materials (metals, plastic, other) and trash (hazardous and non-hazardous).
   c. Effective on-site stormwater containment during all construction and deconstruction activities that prevents any on-site water from reaching the waters of Rock Slough.
   d. All equipment and materials will be temporarily or permanently stored or placed a sufficient distance away from the waterfront to prevent accidental releases of fuels, lubricants, fluids, packaging, *etc.*, from quickly reaching Rock Slough before corrective actions can be implemented.
   e. A Spill Prevention Control and Countermeasure Plan will be prepared to minimize the potential for accidental spills of hazardous materials into Rock Slough during construction of the bridge.
   f. An environmentally sensitive area fence will be installed prior to bridge construction to isolate the area to prevent unnecessary encroachment into the areas adjacent to the construction site.

(3) For any work on or beneath fixed decking, heavy-duty mesh containment netting or other engineering approach will be maintained below all work areas where construction discards or other debris could enter the water.

(4) A floating containment boom, netting, or functional equivalent will be placed around all active portions of a construction/deconstruction site where any floating debris could enter the water. Deployment anchors will be used with all booms to ensure that the boom remains open and capable of collecting any floating debris.
(5) All floating booms or similar containment devices used to collect floating debris as well as any temporary decking or netting placed under overwater structures will be cleaned daily or more frequently if significant debris is being collected.
(6) In addition to deploying booms, a small, motored boat will be on site to capture and recover any floating debris that escapes the containment booms.
(7) Adequate spill prevention measures will be in place to prevent the transfer of any hydrocarbon materials from entering the water while equipment is being used during construction and deconstruction, as well as when being serviced and/or parked.
(8) Provisions will be made to ensure that no external wrapping, internal packing materials, strapping, pallets, boxes, crates, drums, or other associated waste material from staged on-site construction materials can enter Rock Slough.

The following Best Management Practices (BMPs) will be implemented, where applicable, to reduce erosion during construction.

(1) Implementation of the Project will require approval of a site-specific Storm Water Pollution Prevention Plan by the Central Valley Regional Water Quality Control Board (CVRWQCB). This plan includes effective measures to protect water quality, which may include a hazardous spill prevention plan and additional erosion prevention techniques;
(2) A specific work schedule will be implemented to coordinate the timing of land disturbing activities and the installation of erosion and sedimentation control practices to reduce on site erosion and off-site sedimentation;
(3) Existing vegetation will be protected in place where feasible to provide an effective form of erosion and sediment control, as well as watershed protection, landscape beautification, dust control, pollution control, noise reduction, and shade;
(4) Loose bulk materials will be applied to the soil surface as a temporary cover to reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff;
(5) Stabilizing materials will be applied to the soil surface to prevent the movement of dust from exposed soil surfaces on construction sites as a result of wind, traffic, and grading activities;
(6) Roughening and terracing will be implemented to create unevenness on bare soil through the construction of furrows running across a slope, creation of stair steps, or by utilization of construction equipment to track the soil surface. Surface roughening or terracing reduces erosion potential by decreasing runoff velocities, trapping sediment, and increasing infiltration of water into the soil, aiding in the establishment of native vegetative cover from seed;
(7) All landscaping and revegetation will consist of a biologist-approved plant and/or seed mix from native, locally adapted species; and
(8) Prior to arrival at the Project site and prior to leaving the Project site, construction equipment that may contain invasive plants and/or seeds will be cleaned to reduce the spreading of noxious weeds.

2. Minimize Pile Driving Noise

Prior to the start of in-water construction for the Rock Slough Bridge, the applicant will develop a NMFS-approved sound attenuation reduction and monitoring plan. This plan will provide detail on the sound attenuation system, detail methods used to monitor and verify sound levels during pile driving activities, and all BMPs to be taken to reduce impact hammer pile-driving sound in the aquatic environment to an intensity level of less than 183 decibels (dB). The sound monitoring results will be provided to NMFS. The plan will incorporate, but not be limited to the following BMPs:

(1) All pile driving for 24-inch steel trestle piles and 48-inch CISS pilings, will be conducted during the day from August 1–October 15 work window.
(2) Pilings will first be driven using vibratory hammers, if possible. If the vibratory hammer cannot reach the required depth, use of impact hammers may be required.
(3) If exceedance of noise thresholds that have been established and approved by NMFS occur, a contingency plan using bubble curtains or a bubble tree will be implemented to attenuate sound levels to below thresholds.
(4) The impact hammer will be cushioned using a minimum 12-inch-thick wood cushion block during all impact hammer pile driving operations. Cushion blocks will be replaced frequently to maintain maximum sound reduction.
(5) Other BMPs will be implemented as appropriate to reduce underwater noise levels to acceptable levels.

3. Stormwater Discharge Best Management Practices (BMPs)

Mitigation of potential water-quality impacts will be carried out on a property-by-property basis within the Project. Each developer will be required to comply with applicable regulations and standards pertaining to water quality both during and after construction. The water-quality regulations and standards include those associated with the National Pollutant Discharge Elimination System (NPDES) permit as administered by the City of Oakley, the County of Contra Costa (through the Contra Costa Clean Water Program), and the CVRWQCB.

Compliance will be documented in Stormwater Management Plans for each development as it is permitted. The Stormwater Management Plan will describe the strategy for maintaining and/or enhancing the quality of stormwater runoff including the specific measures that will be implemented. The measures will include a framework of BMPs that have proven effective at numerous locations throughout the state.

Source control of pollutants limits the release of pollutants into the stormwater system and serves an important early role in reducing urban pollutants. The following source control measures are included in the Preliminary Stormwater Management Plan (Reclamation 2016):

(1) regular street sweeping by the City of Oakley;
(2) development of chemical application management plans;
(3) training for all landscaping staff;
(4) cleaning of storm drain inlets;

(5) stenciling of all storm drain inlets with the words "No Dumping"; and
(6) outreach and education programs regarding source control would be carried out by the City and County through the ongoing programs of the Contra Costa Clean Water Program.

The lakes proposed for the site would serve as a central treatment control element for much of the Project. The lake designs would incorporate a number of features that would serve to improve the quality of water that is stored and pumped from the lakes that eventually reaches the adjacent sloughs. Each lake would be lined with clay to eliminate contact with the shallow ground water that characterizes the area. The lakes would also include aeration, circulation, and filtration systems to improve control of nutrient loads and algal growth. In addition, the lake pump stations would be programmed so that the required stormwater treatment volume is detained in the lake system for a minimum of 48 hours to enhance the removal of sediment, biological uptake, photodegradation and other pollutant removal mechanisms.

The Project applicant will ensure that proposed Rock Slough Bridge will be designed so that no stormwater from the bridge will drain into Rock Slough since this could impact the water quality at CCWD's Rock Slough Fish Screen Intake.

4. Mitigation Measures

The Project is a Planned Participant in the East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP) which covers impacts to covered threatened and endangered terrestrial species, but not aquatic species such as salmon and steelhead. The Project applicant is currently working with the East Contra Costa County Habitat Conservancy on the Planning Survey Report.

The permanent loss of 100.5 square feet (0.002 acre) of benthic habitat from the permanent bridge piles and the degradation of 9,565 square foot (0.22 acre) of habitat by shading from the proposed Rock Slough Bridge have been fully mitigated through purchase of three conservation credits (one acre each) from the Kimball Island Mitigation Bank. 34 species of juvenile and adult fishes were collected in surveys on Kimball Island from 2002 through 2005, 14 of which were native to the Delta (Wildlands, Inc. 2006). Native species comprised 10% of the total catch and included Sacramento splittail, hitch, Sacramento pikeminnow, tule perch, Chinook salmon, steelhead, delta smelt, threespine stickleback, and prickly sculpin. Sampling at river and breach locations resulted in the highest concentration of native fish species. 69 Chinook salmon, 33 delta smelt, and 6 steelhead were collected during fish monitoring from 2002–2005.

A summary of the Kimball Island Mitigation was provided to NMFS by Tenera on February 4, 2016. The three credits were purchased by the previous Project applicant from the Kimball Island Mitigation Bank on September 20, 2006, and were classified as riverine aquatic-bed credits. The creation of the Kimball Island Mitigation Bank was successful in fulfilling its goals of creating self-sustaining vegetation communities that closely resemble the aquatic, wetland, and riparian habitats found in the Sacramento-San Joaquin Delta (Wildlands, Inc. 2006).

5. Project Timeline

The construction of the Rock Slough Bridge is anticipated to start in August of 2016 and be completed by 2017. The development of the residential and commercial areas will depend on market demand, but is likely to take place in phases over the next 15 years, with the Project completed by 2030.

The process for the development inside the Project is that the applicant, ACD-TI Oakley, LLC, will construct all necessary infrastructure improvements for a master planned community, including the stormwater retention lakes, before the houses and commercial buildings are built. ACD-TI Oakley, LLC, will secure the necessary permits from the Corps, Federal Emergency Management Agency, and the RWQCB before development takes place. Therefore, even though the development will occur in phases over the next 15 years, the stormwater treatment facility for the Project will be built first.

1.4 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 1,246.4-acre Project is located east of Jersey Island Road, north of Rock Slough, south of Dutch Slough, in Sections 21, 27, 28, 33, and 34 Township 2 North, Range 3 East, Mount Diablo Meridian, Latitude 37°59'32.82" North, Longitude 121°38'50.22" West, within the City of Oakley, eastern Contra Costa County, in the western Delta. The site is bounded by Jersey Island Road to the west, the Contra Costa Canal to the south and southwest, Rock Slough to the south, Sandmound Slough to the east, and Dutch Slough to the north (Figure 1). The site is comprised of five undeveloped parcels, partially separated by scattered rural residential development along East Cypress Road. Unlike much of the Delta, the site has not subsided deeply and still has topographic diversity. The Project is located within the leveed Reclamation District 799 (RD799), also referred to as the Hotchkiss Tract, in the Secondary Zone of the Delta. This Zone includes Jersey Island and Bethel Island to the north.

The action area is defined as the extent of the hydroacoustic effects (underwater sound) from pile driving (Figure 4). The portion of the Delta that could be affected by sound levels during pile driving is confined to approximately 2.85 miles of Rock Slough. This is the distance at which sound reaches background levels. Hydroacoustic effects includes all the waters within Rock Slough up to the junction with Sandmound Slough. The maximum extent of the area of direct and indirect effects (*e.g.*, turbidity, construction noise) from the Rock Slough Bridge is 2.85 miles. The proposed Rock Slough Bridge is to be constructed approximately 250 feet downstream from the entrance to CCWD's CCC Intake and Rock Slough Fish Screen which are owned by Reclamation and operated by CCWD (Figure 4).

Additionally, the Project will have water quality impacts from the periodic discharge of stormwater into Sandmound and Dutch Slough. The extent of Project effects resulting from periodic discharge of treated stormwater to Sandmound Slough and Dutch Slough is difficult to quantify. To be conservative, the maximum extent of the area of direct and indirect effects in

Sandmound Slough is estimated to be its entire length of approximately 2.2 miles, of which 0.4 mile are upstream and 1.8 miles are downstream of the RD 799 Pump Station 4. The maximum extent of the action area in Dutch Slough, conservatively, is its entire length of approximately 3.2 miles; Pump Station 2 is located 1.2 miles west of northern terminus of Sandmound Slough.

The shoreline around the three sides of the Project are armored with loose rip-rap and rock that is mostly non-vegetated. Water depth varies from 10–20 feet below mean sea level (MSL) in Dutch Slough (Reclamation 2015), 6–13 feet in Sandmound Slough (Delta Map), and 3–8 feet in Rock Slough. Using Rock Slough as a surrogate for the two other sloughs, Reclamation (2015) found surface elevation varies from 1–4 feet depending on the tide at mean higher high water (MHHW). Tidal velocities for the general area are predicted to be 1.2 knots at maximum ebb tide and a maximum flow rate of 0.7 knots (Reclamation 2012). Small areas of marsh and aquatic vegetation occur along the water's edge and at the junctions of sloughs. Rooted submerged aquatic vegetation was observed in Rock Slough, Sandmound Slough, and Dutch Slough during the October 28, 2015, site visit. Plant species along the shoreline include: giant reed (*Arundo donax*), bulrush (*Bolboschoenus* spp.), soft rush (*Juncus effuses*), large leather-root (*Hoita macrostachya*), Himalayan blackberry (*Rubus armeniacus*), Hottentot fig (*Carpobrotus edulis*), and arroyo willow (*Salix lasiolepis*). Extending from the top of the slough bank to the upland area is largely ruderal and devoid of vegetation, except for 2 small preserves; one at the southeast corner of Rock Slough and Sandmound Slough and one at the northwest corner on Dutch Slough.

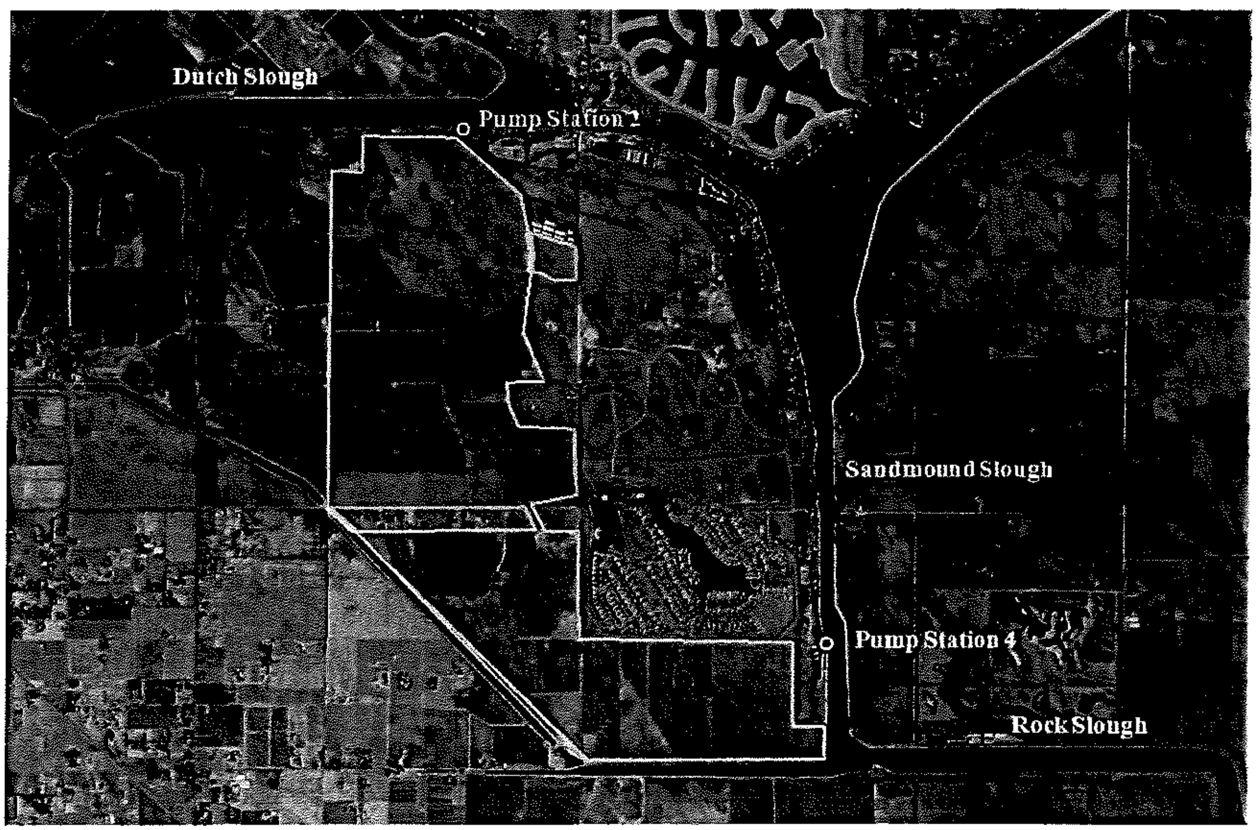

Figure 4. NMFS action area for direct and indirect effects includes the Project area (yellow) and surrounding waters of Dutch Slough, Sandmound Slough, and Rock Slough (blue).

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 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 Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon. Their designated critical habitat are not found in the action area. The analysis is found in the "Not Likely to Adversely Affect Determinations section 2.11.

2.1 Approach to the Analysis

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

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[2]

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 an "exposure-response-risk" approach.

[2] 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).

- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of listed species' component populations in a "viable salmonid populations" (VSP) paper (McElhany *et al.* 2000). The VSP approach considers four population viability parameters (*i.e.*, abundance, productivity, spatial structure, and diversity) as part of the overall review of a species status. In describing the range-wide status of listed species, NMFS relies on viability assessments and criteria in technical recovery team documents and recovery plans, which describe how VSP criteria are applied to specific populations, major population groups, and species. For critical habitat, NMFS determines the range-wide status of critical habitat by examining the condition of its physical or biological features (PBFs), which were formerly called primary constituent elements (PCEs). The new critical habitat regulations in 2016 (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

Once the condition of the critical habitat has been identified within the action area, NMFS determines how the habitat will change due to the Project and whether that change reduces the conservation value of critical habitat over its entire range. The status of the species and critical habitats are discussed in Section 2.2 of this opinion.

NMFS generally approaches "jeopardy" and adverse modification analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors, or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response, including behavioral reactions, to these effects. These responses then will be assessed to determine if they can reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

1. Information Available for the Assessment

To conduct the assessment, NMFS examined an extensive amount of evidence from a variety of sources. Detailed background information on the status of the species and critical habitats has been published in a number of documents, including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, scientific meetings, and environmental reports. Additional information investigating the effects of the Project on the listed anadromous fish species, their anticipated responses to the Project, and the environmental consequences of the Project was obtained from email messages and telephone conversations from October 2015 to April 2016. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document.

2. Assumptions Underlying this Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

For tidal flow volumes, Dutch Slough and Sandmound Slough are assumed to be greater than Rock Slough due to their larger channel size and closer proximity to Big Break, therefore, they would have greater dispersion rates for stormwater discharges. The change in surface elevation with tides was similar between Dutch Slough and Rock Slough (Balance Hydrologics 2015). NMFS assumed that the tidal flow velocities at the Rock Slough Bridge site were similar to those measured at the CCWD Fish Screen, since the depth and channel width are similar between locations (Reclamation 2012). Also, all the sloughs had similar rooted and floating aquatic vegetation during all months of the year (Figure 4, and 22).

For assessing the hydroacoustic impacts of pile driving, NMFS relied on guidance provided in ICF and Illingworth and Rodkin (2009). NMFS assumed that sound data on similar-sized piles were appropriate to use when the Project piles were not exactly the same size. Sound data for various sized piles were obtained from data compiled in the Compendium Report for the California Department of Transportation (Illingworth and Rodkin 2007).

In assessing the effects of the Project, NMFS used additional information from fish monitoring studies conducted by CDFW, USFWS, and at the Delta Fish Salvage Facilities regarding salmonid density in the San Joaquin River and Sacramento River for use in risk assessment.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as the Central Valley Recovery Plan (NMFS 2014), status reviews (NMFS 1998, 2011a, 2011b, 2011c, and 2015), and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

The opinion analyzes the effects of the Federal action on the endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, and threaten Southern distinct population segment (DPS) of North American green sturgeon (sDPS green sturgeon). Although most salmonids will not be present during the construction work window, stormwater discharge will occur when salmonids are present. Therefore the status of winter-run Chinook salmon and CV spring-run Chinook salmon is included. This opinion also analyzes the effects of the Federal action on designated critical habitat for CCV steelhead and sDPS green sturgeon. Due to the Project location in the south Delta, the action area does not include designated critical habitat for winter-run Chinook salmon, or CV spring-run Chinook salmon (58 FR 33212, and 70 FR 52488, respectively), therefore, these habitats are not described here.

2.2.1 Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit (ESU)

- First listed as threatened (August 4,1989, 54 FR 32085), reclassified as endangered (January 4, 1994, 59 FR 440),
- Reaffirmed as endangered (June 28, 2005, 70 FR 37160 and August 15, 2011, 76 FR 50447)

A. Species Listing History

The Sacramento River winter-run Chinook salmon (winter-run, *Oncorhynchus tshawytscha*) ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085), and formally listed as a threatened species in November 1990 (55 FR 46515). On January 4, 1994, NMFS re-classified winter-run as an endangered species (59 FR 440). NMFS concluded that winter-run in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run (August 15, 2011, 76 FR 50447).

On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of five Pacific salmon ESUs, including the winter-run ESU, and determined that the species' status should again remain as "endangered" (August 15, 2011, 76 FR 50447).

The 2011 review concluded that although the listing remained unchanged since the 2005 review, the status of the population had declined over the past five years (2005–2010).

The winter-run ESU currently consists of only one population that is confined to the upper Sacramento River (spawning below Shasta and Keswick dams) in California's Central Valley. In addition, an artificial conservation program at the Livingston-Stone National Fish Hatchery (LSNFH) produces winter-run that are considered to be part of this ESU (June 28, 2005, 70 FR 37160). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Remaining spawning and rearing areas are completely dependent on cold water releases from Shasta Dam in order to sustain the remnant population.

B. Winter-run Chinook Life History

1. Adult Migration and Spawning

Winter-run exhibit a unique life history pattern (Healey 1994) compared to other salmon populations in the Central Valley (*i.e.*, spring-run, fall-run, and late-fall run), in that they spawn in the summer, and the juveniles are the first to enter the ocean the following winter and spring. Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (Table 1).

Winter-run tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (Healey 1991). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River reach (50 miles) between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run deposit and fertilize eggs in gravel beds known as redds excavated by the female that then dies following spawning. Average fecundity was 5,192 eggs/female for the 2006–2013 returns to LSNFH, which is similar to other Chinook salmon runs [*e.g.*, 5,401 average for Pacific Northwest (Quinn 2005)]. Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature is between 55–57°F (13–14°C) degrees (Snider *et al.* 2001). The majority of winter-run adults return after three years.

Table 1. The temporal occurrence of adult (a) and juvenile (b) winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

Winter run relative abundance	High				Medium				Low			
a) Adults freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]												
Upper Sacramento River spawning[c]												
b) Juvenile emigration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff[d]												
Sacramento River at Knights Landing[e]												
Sacramento trawl at Sherwood Harbor[f]												
Midwater trawl at Chipps Island[g]												

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)

2. Egg and Fry Emergence

Winter-run incubating eggs are vulnerable to adverse effects from floods, flow fluctuations, siltation, desiccation, disease, predation during spawning, poor gravel percolation, and poor water quality. The optimal water temperature for egg incubation ranges from 46–56°F (7.8–13.3°C) and a significant reduction in egg viability occurs at mean daily water temperatures above 57.5°F (14.2°C); (Seymour 1956, Boles 1988, USFWS 1998, USEPA 2003, Geist *et al.* 2006). Total embryo mortality can occur at temperatures above 62°F (16.7°C) (NMFS 1997). Depending on ambient water temperature, embryos hatch within 40-60 days and alevin (yolk-sac fry) remain in the gravel beds for an additional 4–6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding in their natal stream, typically in late July to early August and continuing through October (Fisher 1994).

3. Juvenile Rearing and Outmigration

Juvenile winter-run have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman *et al.* 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only 4 to 7 months of river life, while others hold and rear upstream and spend 9 to 10 months in freshwater. Emigration of juvenile winter-run fry and pre-smolts past

RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September (Table I), and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997).

4. Estuarine/Delta Rearing

Juvenile winter-run emigration into the Delta and estuary occurs primarily from November through early May based on data collected from trawls in the Sacramento River at Sherwood Harbor (West Sacramento), RM 57 (USFWS 2013). The timing of emigration may vary somewhat due to changes in river flows, Shasta Dam operations, and water year type, but has been correlated with the first storm event when flows exceed 14,000 cfs at Knights Landing, RM 90, which trigger abrupt emigration towards the Delta (del Rosario *et al.* 2013). The average residence time in the Delta for juvenile winter-run is approximately 3 months based on median seasonal catch between Knights Landing and Chipps Island. In general, the earlier juvenile winter-run enter the Delta, the longer they stay and rear. Peak departure at Chipps Island regularly occurs in March (del Rosario *et al.* 2013). The Delta serves as an important rearing and transition zone for juvenile winter-run as they feed and physiologically adapt to marine waters during the smoltification process (*i.e.,* change from freshwater to saltwater). The majority of juvenile winter-run in the Delta are 104 to 128 millimeters (mm) in size, based on USFWS trawl data (1995–2012), and are from 5 to 10 months of age by the time they depart the Delta (Fisher 1994, Myers *et al.* 1998, USFWS 2013).

5. Ocean Rearing

Winter-run smolts enter the Pacific Ocean mainly in spring (March–April), and grow rapidly on a diet of small fishes, crustaceans, and squid. Salmon runs that migrate to sea at a larger size tend to have higher marine survival rates (Quinn 2005). The diet composition of Chinook salmon from California marine waters consists of (in order of preference): anchovy, rockfish, herring, and other invertebrates (Healey 1991). Most Chinook from the Central Valley move northward into Oregon and Washington, where herring make up the majority of their diet. However, winter-run upon entering the ocean, tend to distribute southward from Point Arena to Monterey Bay near the California coast. Winter-run have high metabolic rates, feed heavily, and grow fast, compared to other fishes in their range. They can double their length and increase their weight more than ten-fold in the first summer at sea (Quinn 2005). Mortality is typically highest in the first summer at sea, but can depend on ocean conditions. Winter-run abundance has been correlated with ocean conditions, such as periods of strong up-welling, cooler temperatures, and El Nino events (Lindley *et al.* 2009). Winter-run spend approximately 1-2 years rearing in the ocean before returning to the Sacramento River as 2-3 year old adults. Very few winter-run reach age 4. Once they reach age 3, they are large enough to become vulnerable to commercial and sport fisheries.

C. Description of Winter-run Viable Salmonid Population (VSP) Parameters

1. Abundance

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (NMFS 2011c). In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. However, from 2007 to 2013, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 (Figure 5). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009), drought conditions from 2007–2009, and low in-river survival (NMFS 2011c). In 2014, the population was 3,015 adults, slightly above the 2007–2012 average, but below the high (17,296) for the last 10 years.

Although impacts from hatchery fish (*i.e.*, reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the winter-run conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes RBDD, which is 4.7 million per year based on the 2002–2010 average (Poytress and Carrillo 2011). Hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year. However, due to drought conditions, natural in-river production to the Delta declined to just 124,521 juveniles in 2014 (Table 3). 2014 was the third year of a drought which increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the RBDD was approximately 5 percent. Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled (*i.e.*, 612,056 released) to offset the impact of the drought. In 2014, hatchery production represented 83% of the total in-river juvenile production. In 2015, egg-to-fry survival was the lowest on record (~4 percent), due to the inability to release cold water from Shasta Dam in the fourth year of a drought. Winter-run returns in 2016 are expected to be low as they show the impact of drought on juveniles from brood year 2013.

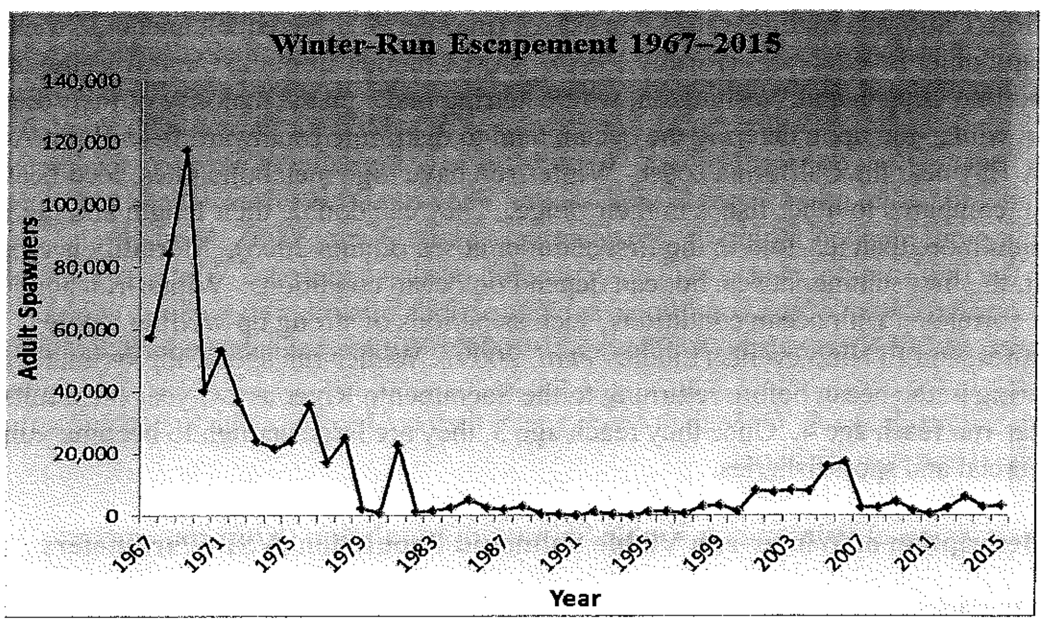

Figure 5. Winter-run Chinook salmon escapement 1967-2015, based on ladder counts and carcass surveys after 2001, includes hatchery broodstock and tributaries, but excludes sport catch (CDFW 2015).

2. Productivity

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative (Figure 6) with declining escapement estimates. The long-term trend for the ESU remains unknown, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) suggests the population is not stable (Figure 6), and from 2007–2012 the population was not replacing itself. From 2013 and 2015, winter-run experienced a positive CRR, possibly due to favorable in-river conditions in 2011, and 2012 (wet and below normal, respectively), which increased juvenile survival to the ocean.

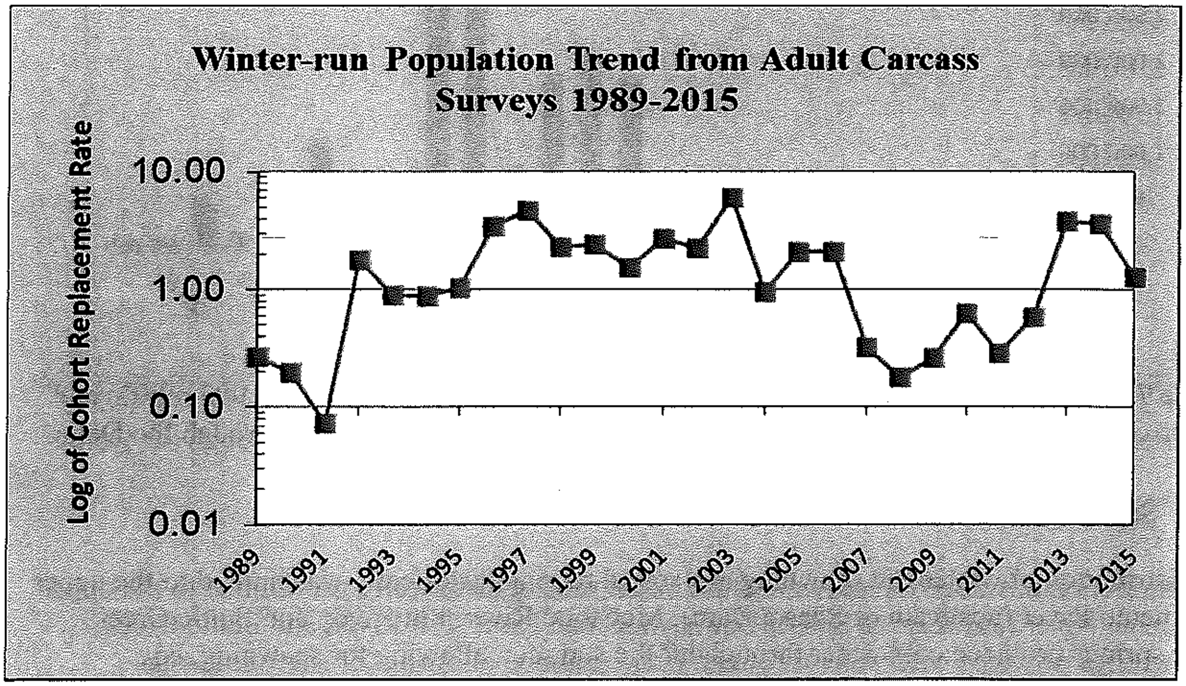

Figure 6. Winter-run population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1989–2015.

An age-structured density-independent model of spawning escapement by Botsford and Brittnacher (1998) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females. Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the growth rate for the winter-run population improved up until 2006, it exhibits the typical variability found in most endangered species populations. The fact that there is only one population, dependent upon cold-water releases from Shasta Dam, makes it vulnerable to periods of prolonged drought (NMFS 2011c). Productivity, as measured by the number of juveniles entering the Delta, or juvenile production estimate (JPE), has declined in recent years from a high of 3.8 million in 2007 to 124,521 in 2014 (Figure 7). Due to uncertainties in the various JPE factors, the JPE was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences mortality model), and again in 2013, and 2014 with improved survival rates based on recent acoustic tag data (NMFS 2014). However, juvenile winter-run productivity remains lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

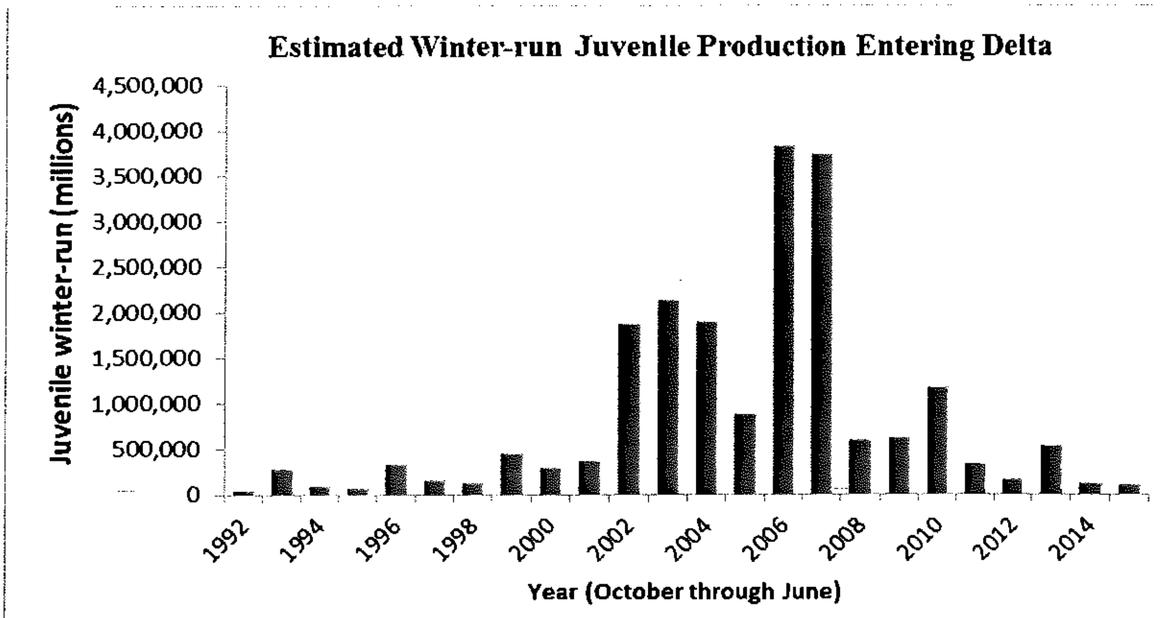

Figure 7. Winter-run juvenile population estimates based on RBDD counts (1992–2001) and carcass counts (2001–2015). Estimates include survival to the Delta but not through the Delta.

3. Spatial Structure

The distribution of winter-run spawning and initial rearing historically was limited to the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963 *op. cit.* Yoshiyama *et al.* 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration (*i.e.*, a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery [Coleman NFH] weir). The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, which should restore spawning and rearing habitat for winter-run in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run. Yoshiyama *et al.* (2001) estimated that in 1938, the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for winter-run lies within its spatial structure (NMFS 2011c). The remnant and remaining population cannot access 95 percent of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and, (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures. Winter-run require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2017. The Central Valley Recovery Plan (NMFS 2014) includes criteria for recovering the winter-run ESU, including re-establishing a population into historical habitats upstream of Shasta Dam. Additionally, NMFS (2009) biological opinion on long-term water project operations included a requirement for a fish passage program above Shasta Dam.

4. Diversity

The current winter-run population is the result of the introgression of several stocks (*e.g.,* spring-run and fall-run Chinook salmon) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007) recommended reclassifying the winter-run population extinction risk from low to moderate, if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery winter-run spawning in the Sacramento River has only exceeded 15 percent in four years, 2005, 2012, 2014, and 2015 (Figure 8).

Concern over genetic introgression within the winter-run population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run have made up more than 5 percent of the natural spawning run in recent years and in 2012, it exceeded 30 percent of the natural run (Figure 8). However, the average over the last 18 years (approximately 6 generations) has been only 9.3 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley *et al.* 2007). Drought conditions persisted in 2015 and hatchery production was increased again to 420,000 juveniles released, which was three times greater than what was produced naturally in-river (101,716).

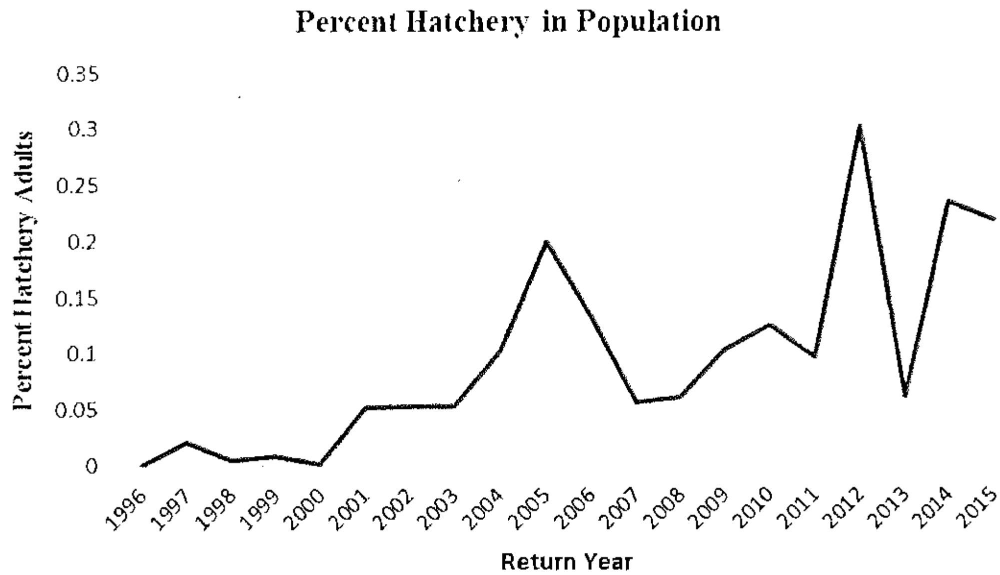

Figure 8. Percentage of hatchery-origin winter-run naturally spawning in the Sacramento River (1996–2015). Source: unpublished data, (CDFW 2015).

5. Summary of 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 below 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 (Figure 6); (2) a negative growth rate over the 6 years from 2006–2012, which is two complete generations (Figure 7); (3) a declining trend in juvenile production since 2007 (Table 3); and (4) increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change). The most recent 5-year status review (NMFS 2011c) on winter-run concluded that the ESU had increased to a high risk of extinction. 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 (last review), and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (NMFS 2011c).

The current condition of critical habitat for the winter-run ESU is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat of the Sacramento River. Within the Sacramento River, essential features of critical habitat (*i.e.*, migration corridor, adequate temperature, flows) have been impacted by human actions, substantially altering the historical river characteristics in which the winter-run ESU evolved. In the Delta, the man-made alterations may have a strong impact on the survival and recruitment of juvenile winter-run due to changes in migration routes and their dependence on migration cues like high flows and increased turbidity.

2.2.2 Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU)

- Originally listed as threatened September 16, 1999, 64 FR 50394
- Reaffirmed as threatened (June 28, 2005, 70 FR 37160)
- designated critical habitat (September 2, 2005, 70 FR 52488)

A. Species Listing and History

Central Valley (CV) spring-run Chinook salmon (spring-run) were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run population has been included as part of the spring-run ESU in the most recent spring-run listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run production is included in the ESU, these fish do not have a section 9 take prohibition.

In August 2011, NMFS completed an updated status review of five Pacific Salmon ESUs, including spring-run, and concluded that the species' status should remain as previously listed (76 FR 50447). The 2011 Status Review (NMFS 2011a) additionally stated that although the listings will remain unchanged since the 2005 review, and the original 1999 listing (64 FR 50394), the status of these populations has worsened over the past five years and recommended that the status be reassessed in two to three years as opposed to waiting another five years.

B. Spring-run Chinook Life History

1. Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult spring-run leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River beginning in March (Yoshiyama *et al.* 1998). Spring-run move into tributaries of the Sacramento River (*e.g.*, Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley *et al.* 2004, see Table 2). Typically, spring-run utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 3°C (38°F) to 13°C (56°F) (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 18°C (65°F) for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 21°C (70°F), and that fish can become stressed as temperatures approach 21°C (70°F).

Reclamation reports that spring-run holding in upper watershed locations prefer water temperatures below 15.6°C (60°F); although salmon can tolerate temperatures up to 18°C (65°F) before they experience an increased susceptibility to disease (Williams 2006).

2. Adult Spawning

Spring-run spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult spring-run that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994); spring-run tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

Spring-run spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995, NMFS 2007). Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Velocity typically ranging from 1.2 – 3.5 feet/second, and water depths greater than 0.15 m (YCWA *et al.* 2007) . The upper preferred water temperature for spawning Chinook salmon is 13°C to 14°C (55°F to 57°F) (Chambers 1956, Smith 1973, and Bjornn and Reiser 1991). Chinook salmon are semelparous (die after spawning).

3. Eggs and Fry Incubation to Emergence

The spring-run embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sac prior to emergence. The length of time for spring-run embryos to develop depends largely on water temperatures. In well-oxygenated intergravel environs where water temperatures range from about 5°C to 13°C (4°F to 55.4°F) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2014). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence conducted by Shelton (1955) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 5°C to 14°C (41°F to 56°F) (NMFS 1997, Rich 1997, Moyle 2002). A significant reduction in egg viability occurs at water temperatures above 14°C (57.5°F) and total embryo mortality can occur at temperatures above 17°C (62°F) (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16°C and 3°C (61°F and 37°F), respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in redds. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The newly emerged fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25–40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

4. Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 2.7 m to 3.0 m in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migration cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of development (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. The daily migration of juveniles passing RBDD is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found that Chinook salmon fry travel as fast as 30 km per day in the Sacramento River. As Chinook salmon begin the smolt stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

Spring-run fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings (Table 2). The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of spring-run migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of spring-run were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). The CDFW (1998) observed the emigration period for spring-run extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile spring-run in the Sacramento River at Knights Landing occurs in December, and again in March and April (Table 2). However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

5. Estuarine Rearing

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, spring-run juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, CDFG 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, MacFarlane and Norton 2002). Shallow water habitats such as floodplains are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 12°C to 14°C (54°F to 57°F) (Brett 1952).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings *et al.* 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 m of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean.

6. Ocean Rearing

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California Current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002, Lindley *et al.* 2009). After entering the ocean, juveniles become voracious predators on small fish and crustaceans, and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic plankton is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The Ocean stage of the Chinook life cycle lasts one to five years. Information on salmon abundance and distribution in the ocean is based upon coded wire tag (CWT) recoveries from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns.

Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement (adult spawner populations that have "escaped" the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

Table 2. 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.

(a) Adult migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[a,b]			High	High	High	High	High	High	High	Low / –		
Sac. River Mainstem[b,c]	– / Low	Low	High	High	High	High	High	Low				
Mill Creek[d]			Low	High	High	High	High / Low	Low / –				
Deer Creek[d]			Low	High	High	High	High / –					
Butte Creek[d,g]		Low / High	High	High	High	High	Low / –					
(b) Adult Holding[a,b]		– / Low	Low / High	High	High	High	High	High / Medium	Medium / Low	Low / –		
(c) Adult Spawning[a,b,c]								Low / High	High	High / Low		

(b) Juvenile migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River Tribs[e]	High	High	High							High	High	High
Upper Butte Creek[f,g]	High	High	High	High	High	Low				Low	Low	High
Mill, Deer, Butte Creeks[d,g]	High	High	High	High	High	Low				Low	Low	Low
Sac. River at RBDD[c]	High	Low	Low	Low	Low / –						High	High
Sac. River at KL[h]	Medium	Medium	High	High	Medium						Medium	High

Relative Abundance: ■ High ■ Medium ▒ Low

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 rear in their natal streams through the first summer following their birth and downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run emigrate during the first spring after they hatch.

D. Description of Spring-run Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the spring-run ESU, and determine the extinction risk of the ESU, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany *et al.* 2000)

1. Abundance

Historically spring-run were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (305 to 1,829 m) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).

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

The FRFH spring-run population represents the only remaining evolutionary legacy of the spring-run populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy, for the hatchery program. On the Feather River, significant numbers of spring-run, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated by the California Department of Water Resources (DWR) using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (DWR 2001). However, after 1981, CDFG ceased to estimate in-river spawning spring-run because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. Spring-run estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,783 fish in 2011 (Table 5). Genetic testing has indicated that substantial introgression has occurred between fall-run and spring-run populations within the Feather River system due to temporal overlap and hatchery practices (DWR 2001). Because Chinook salmon have not always been spatially separated in the FRFH, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run stock (CDFG and DWR 2012, Good *et al.* 2005). In addition, CWT information from these hatchery returns has indicated that fall-run and spring-run have overlapped (DWR 2001). For the reasons discussed above, the FRFH spring-run numbers are not included in the following discussion of ESU abundance trends.

Monitoring of the Sacramento River mainstem during spring-run spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem very difficult to determine, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run abundance. Less than 15 spring-run redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts, while no spring-run redds were observed in 1994 (USFWS 2003). Redd surveys conducted in September from Keswick Dam downstream to the RBDD have observed an average of 36 Chinook salmon redds (2001–2011) ranging from 3 to 105 redds; 2012 observed 0 redds, 2013 observed 57 redds, and 2014 there were no flights in September (CDFW, unpublished data, 2015). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the spring-run ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 5). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000 (although 2008 was nearly 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005, the spring-run ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of spring-run remained well below estimates of historic abundance (Table 3).

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run in Butte Creek due to the diseases.

From 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011a). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011a). Some other tributaries to the Sacramento River, such as Clear

Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). The 2013 escapement numbers increased which resulted in the second highest number of returns since 1998. However, the 2014 and 2015 returns exhibited a progressively declining trend, with slightly less than 10,000 and just over 5,000 spring-run returning in those years, respectively, indicating a highly fluctuating and unstable ESU abundance.

2. Productivity

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

From 1993 to 2007 the 5-year moving average of the tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (Table 3). The productivity of the Feather River and Yuba River populations and contribution to the spring-run ESU currently is unknown, however the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive at 1.85. The 2015 returns had a very low CRR when using the Butte Creek snorkel counts (0.14), which was the lowest on record. Using the Butte Creek carcass surveys, the 2015 CCR for just Butte Creek was only 0.02.

3. Spatial Structure

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of spring-run, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure 9) (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Table 3. Central Valley Spring-run Chinook salmon population estimates with corresponding cohort replacement rates for years since 1986 (CDFW 2014).

Year	Sac. River Basin Run Size[a]	FRFH	Tributary Populations	5-Year Moving Average Tributary Population	Trib CRR[b]	5-Year Moving Average Trib CRR	5-Year Moving Average of Sac R Basin	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.54	4,795	1.63	1.36
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,534	6,746	23,788	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24
2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,869	4,135	12,734	9,917	0.54	2.09	14,301	0.55	1.30
2002	17,224	4,189	13,035	12,242	2.13	2.35	16,733	1.75	1.46
2003	17,691	8,662	9,029	9,290	1.63	2.17	14,165	1.92	1.43
2004	13,612	4,212	9,400	9,948	0.74	1.79	14,919	0.81	1.37
2005	16,096	1,774	14,322	11,704	1.10	1.23	16,298	0.93	1.19
2006	10,948	2,181	8,767	10,911	0.97	1.31	15,114	0.62	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,615	0.71	1.00
2008	6,368	1,624	4,744	8,857	0.33	0.78	11,350	0.40	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,388	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.54	6,927	0.39	0.49
2011	4,967	1,969	3,067	3,961	0.65	0.47	5,731	0.78	0.53
2012	18,275	3,738	10,810	4,713	3.84	1.09	7,441	0.79	0.54
2013	38,556	4,294	18,499	7,464	8.68	2.76	13,878	2.00	0.86
2014	8,434	2,776	5,658	7,186	1.85	2.66	10,073	1.76	0.99
Median	10,085	3,700	6,327	6,326	2.00	1.85	10,034	1.00	1.27

[a] Only includes escapement numbers from FRFH and Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from FRFH and the tributaries.

[b] Abbreviations: FRFH = Feather R Fish Hatchery, CRR = Cohort Replacement Rate, Trib = tributary

Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated spring-run from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running Chinook salmon populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2013).

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

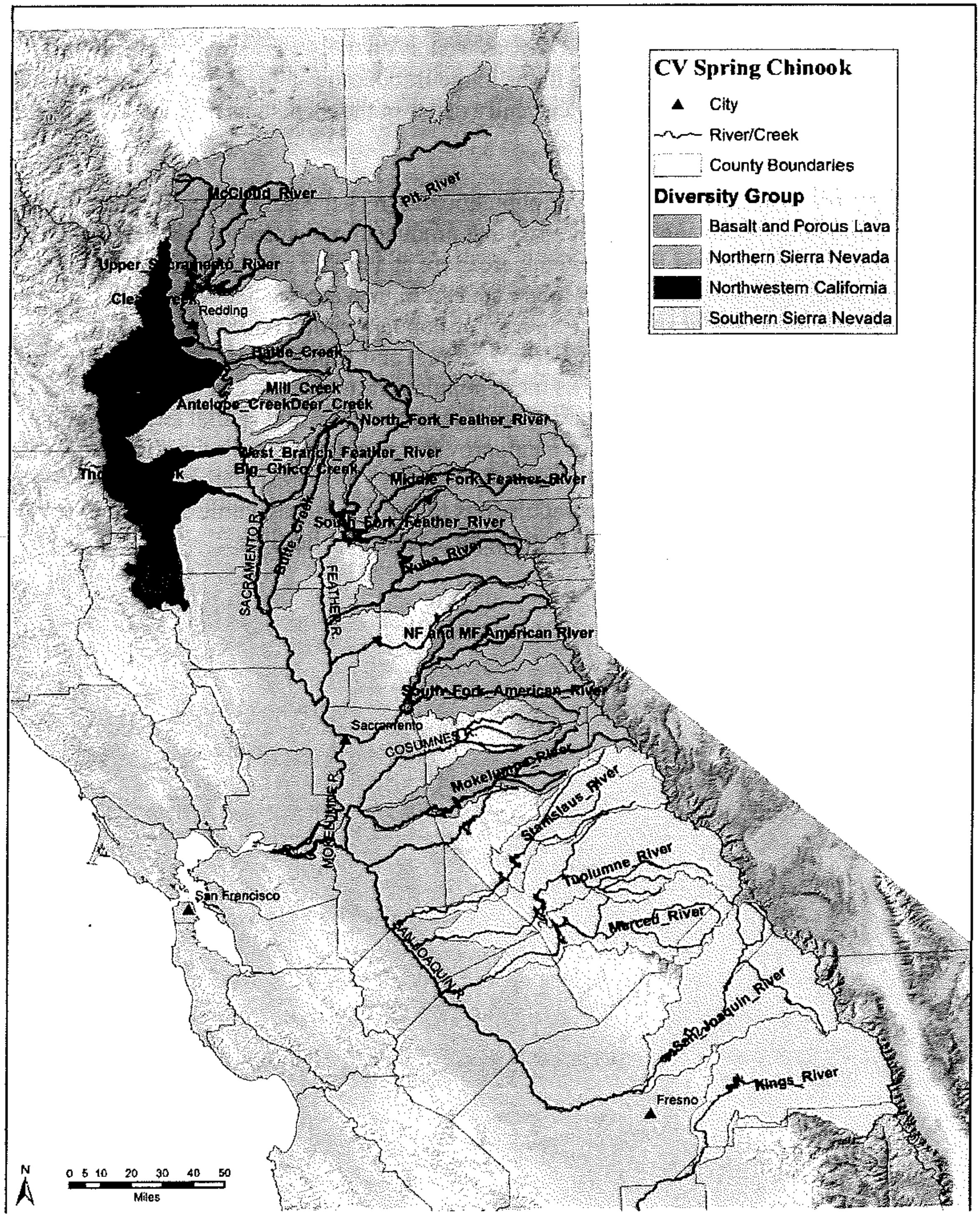

Figure 9. Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

With only one of four diversity groups currently containing viable independent populations, the spatial structure of spring-run is severely reduced. Butte Creek spring-run adult returns are currently utilizing all available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and

Battle Creek, with habitat restoration projects completed and more underway, are anticipated to add to the spatial structure of the spring-run ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the spring-run ESU would still be lacking due to the extirpation of all San Joaquin River basin spring-run populations, however recent information suggests that perhaps a self-sustaining population of spring-run is occurring in some of the San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne rivers.

A final rule was published to designate a nonessential experimental population of spring-run to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (FR 78 FR 251; December 31, 2013). Pursuant to ESA section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking spring-run within the experimental population area, and in specific instances elsewhere. The first release of spring-run juveniles into the San Joaquin River occurred in April, 2014. A second release occurred in 2015, and future releases are planned to continue annually during the spring. The SJRRP's future long-term contribution to the spring-run ESU has yet to be determined.

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate spring-run spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult spring-run (Anderson *et al.* 2007). Genetic testing is needed to confirm that these fish are spring-run, to determine which strain they are. Finally, rotary screw trap (RST) data provided by the USFWS (Lodi Office) corroborates the spring-run adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration (Franks 2013). Plans are underway to re-establish a spring-run Chinook salmon population in the San Joaquin River downstream of Friant Dam, as part of the San Joaquin River Restoration Program. Interim flows for this began and spring-run are expected to be released in 2013. The San Joaquin River Restoration Programs' future long-term contribution to the spring-run ESU is uncertain.

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

4. Diversity

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

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

5. Summary of ESU Viability

Since the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Lindley *et al.* (2007) indicated that the spring-run 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 was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the spring-run 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 NMFS (2014). Over the long term, these three remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Until 2012, the status of the spring-run ESU had 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 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 rate of population decline. In contrast, spring-run 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 NMFS, Southwest Fisheries Science Center concluded in their viability report that the status of the spring-run ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams *et al.* 2011). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

The viability assessment of spring-run conducted during NMFS' 2010 status review (NMFS 2011a) found that the biological status of the ESU had worsened since the last status review in 2005. They recommended that its status be reassessed in two to three years, as opposed to waiting another five years, if the decreasing trend continues and the ESU does not respond positively to improvements in environmental conditions and management actions. In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns decreased to 10,000, and 2015 returns were just over 5,000 fish, indicating the ESU remained unstable. A status review was conducted in 2015 (NMFS 2016), which looked at promising increases in 2012–2014, however the 2015 return was extremely low (1,488 adults), with additional pre-spawn mortality resulting in record low spawning success. Since the effects of the 2012–2015 drought have not been fully realized, NMFS anticipated at least several more years of very low spring-run returns, which may reach catastrophic rates of decline (NMFS 2016).

i. California Central Valley Steelhead distinct population segment (DPS)

- Originally listed as threatened on March 19, 1998 (63 FR 13347)
- Reaffirmed as threatened August 15, 2011 (76 FR 50447)
- Critical habitat designated September 2, 2005 (70 FR 52488)

A. Species Listing and Critical Habitat Designation History

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good *et al.* 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the FRFH and Coleman NFH stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 west coast salmonid ESUs and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR

834). On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011b). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488).

B. Critical Habitat and PBFs for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta (Figure 10). The CCV steelhead designated critical habitat extends up the San Joaquin River to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999; 70 FR 52488). Critical habitat for CCV steelhead is defined as specific areas that contain the PBFs essential to the conservation of the species. Following are the inland habitat types used as PBFs for CCV steelhead.

1. Spawning Habitat

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

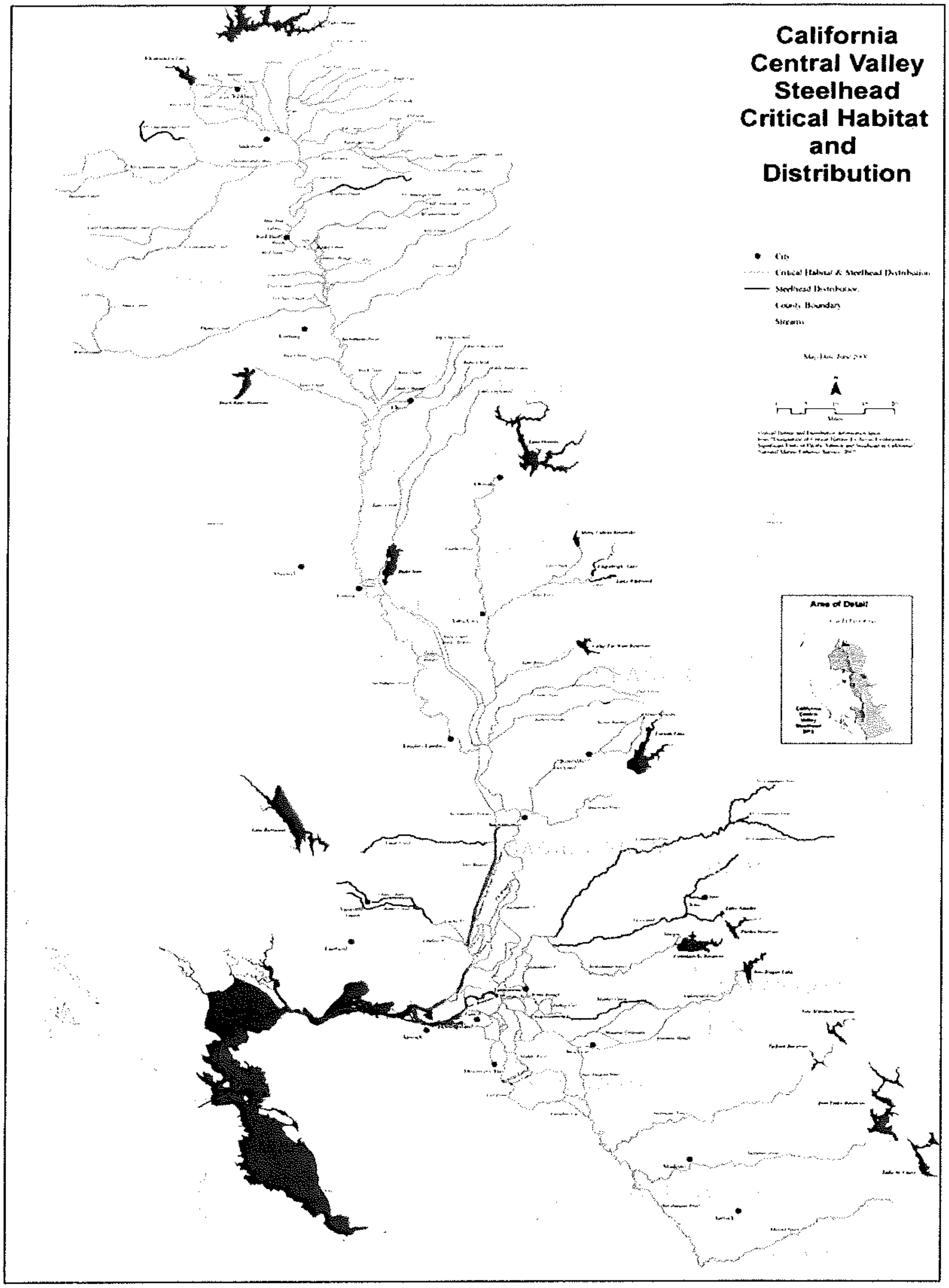

Figure 10. Map of CCV steelhead designated critical habitat.

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 large woody material, 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 material, 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.

5. Summary of CCV Steelhead Critical Habitat

The current condition of critical habitat for CCV steelhead is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat of the San Joaquin River tributaries. In the Delta, the migration corridor and water flow PBFs have been impacted by human actions, substantially altering the historical river characteristics in which the CCV steelhead evolved. In addition, the man-made alterations to the Delta may have a strong impact on the survival and recruitment of juvenile CCV steelhead.

C. CCV Steelhead Life History

1. Egg to Parr

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in three to four weeks at 10°C (50°F) to 15°C (59°F) (Moyle 2002). After hatching, alevins remain in the gravel for an additional two to five weeks while absorbing their yolk sacs, and emerge in spring or early summer (Barnhart 1986). Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986).

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965; Everest and Chapman 1972; Fontaine 1988).

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

2. Smolt Migration

Juvenile steelhead will often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch *et al.* 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage (Table 4).

3. Ocean Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that California steelhead may not migrate to the Gulf of Alaska region of the north Pacific as commonly as more northern populations such as those in Washington and British Colombia. Burgner *et al.* (1993) reported that no coded-wire tagged steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of CCV steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

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

There are no commercial fisheries for steelhead in California, Oregon, or Washington, with the exception of some tribal fisheries in Washington waters. Therefore, there is no ocean harvest of steelhead except for incidental bycatch.

4. Spawning

CCV steelhead generally enter freshwater from August to November with a peak in September (Hallock *et al.* 1961), and spawn from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Table 4). The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman *et al.* 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F maximum daily average water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern as this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct smaller redds than salmon in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

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

Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek. Null *et al.* (2013) found between 36 percent and 48 percent of kelts released from Coleman NFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman NFH in 1971, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider *et al.* 1986).

5. Kelts

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

Table 4. The temporal occurrence of (a) adult and (b) juvenile CCV steelhead at monitoring locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1]Sacramento R. at Fremont Weir	Low	Low	Low / –			– / Low	Low	Low / High	High	High	Low	Low
[2]Sacramento R. at RBDD	Low	Low	Low	Low	Low	Low	Low	Low	High	High	Low	Low
[3]Mill & Deer Creeks	High	High	High / Low	Low	Low	Low				High	High / Low	Low
[4]Mill Creek at Clough Dam	Low	High	High	Low					– / Low	High	High	High
[5]San Joaquin River	High	High	Low				Low	Low	High	High	High	High

(b) Juvenile migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sacramento R. near Fremont Weir	Low	Low	High	High	High	High	Low	Low	Low	High	High	Low
[6]Sacramento R. at Knights Landing	High	High	High	High	Medium	Medium					Low	Low
[7]Mill & Deer Creeks (silvery parr/smolts)	Low	Low	High	High	High	Medium				Low	Low	Low
[7]Mill & Deer Creeks (fry/parr)	Low	Low	Low	Medium	High	High				Medium	Medium	Medium
[8]Chipps Island (clipped)	High	High	High	Low	Low							Low
[8]ChippsIsland (unclipped)	High	High	High	High	High	Medium	Low					Low
[9]San Joaquin R. at Mossdale		Low	High	High	High	Low				Low		
[10]Mokelumne R. (silvery parr/smolts)	Low	High	High	High	High	High	High					
[10]Mokelumne R. (fry/parr)		Low	Low	Low	High	High	High					
[11]Stanislaus R. at Caswell	Low	High	High	High	High	Low						
[12]Sacramento R. at Hood	Low	High	High	High	High	High / –					Low	Low

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

Sources: [1](Hallock 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998-2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998-2011 USFWS data; [9]NMFS analysis of 2003-2011 USFWS data; [10]unpublished EBMUD RST data for 2008-2013; [11]Oakdale RST data (collected by FishBio 2012-2014); [12](Schaffter 1980).

D. Description of CCV Steelhead Viable Salmonid Population (VSP) Parameters

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

1. Abundance

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

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

Coleman NFH operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the CCV steelhead DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman NFH stopped transferring adipose-fin clipped steelhead above the weir, resulting in a large decrease in the overall numbers of steelhead in Battle Creek above the weir in recent years (Figure 11). In 2003, Coleman NFH transferred about 1,000 clipped adult steelhead to Keswick Reservoir. These fish are not included in the data. In addition, in 2015, Coleman NFH transferred 200,000 steelhead eggs to Nimbus Fish Hatchery due to low returns to the American River. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery and natural-origin steelhead in Battle Creek were not differentiable, and all steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin steelhead in Battle Creek began in 2001. These estimates of steelhead abundance ranged from 74 to 401 (2002-2014) include all *O. mykiss*, including resident and anadromous fish (Figure 11).

Steelhead returns to Coleman NFH have fluctuated greatly over the years. From 2003 to 2014 the number of hatchery origin adults has ranged from 624 to 2,968. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200-500 fish each year (Figure 12).

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 151 redds have been counted in Clear Creek from 2001 to 2010 (Figure 14; data from USFWS), and an average of 154 redds have been counted on the American River from 2002-2010 (Figure 13); data from (Hannon and Deason 2008, Hannon *et al.* 2003, Chase 2010).

The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season, and the overall trend is a slight increase. However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite *et al.* 2010), which are not part of the CCV steelhead DPS.

The returns of steelhead to the FRFH have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 15). This is despite the fact that almost all of these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. However, return data for 2011 shows a slight rebound in numbers, with 712 adults returning to the hatchery (CDFG 2011, unpublished data).

The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001 (Figure 14). The average redd index from 2001 to 2011 is 157, representing somewhere between 128 and 255 spawning adult steelhead on average each year. The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the proportion of wild steelhead relative to hatchery steelhead (CDFW, ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure 17). The percentage of unclipped steelhead (wild) in salvage has also fluctuated, but has generally declined since 1998, when all hatchery steelhead were marked. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

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

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2011 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960's and 1970's, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns.

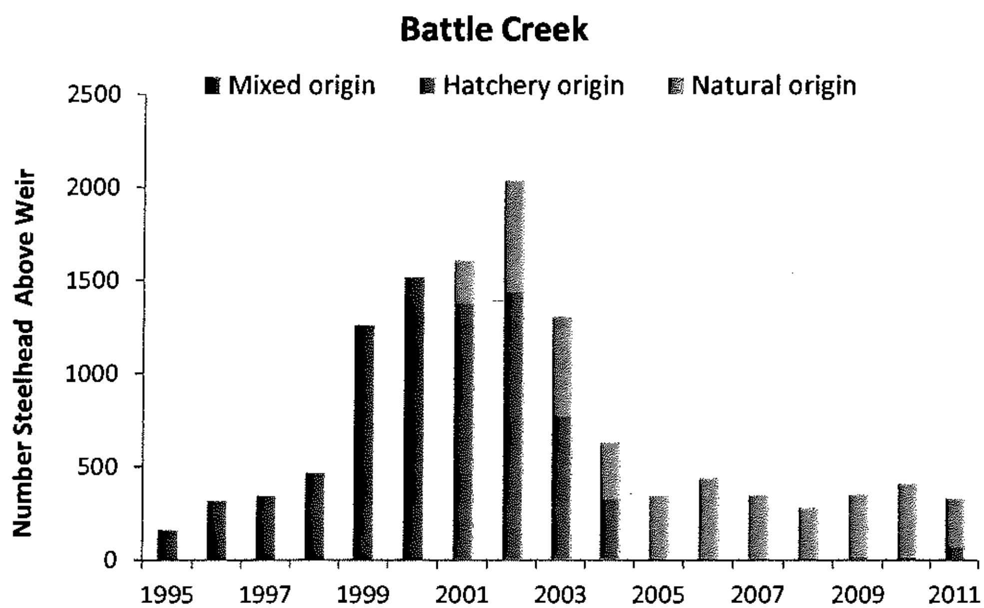

Figure 11. Steelhead returns to Battle Creek from 1995-2009. Starting in 2001, *O. mykiss* were classified as either wild (unclipped) or hatchery produced (clipped). Includes fish passed above the weir during broodstock collection and fish that passed through the fish ladder March 1 to August 31. Data from USFWS.

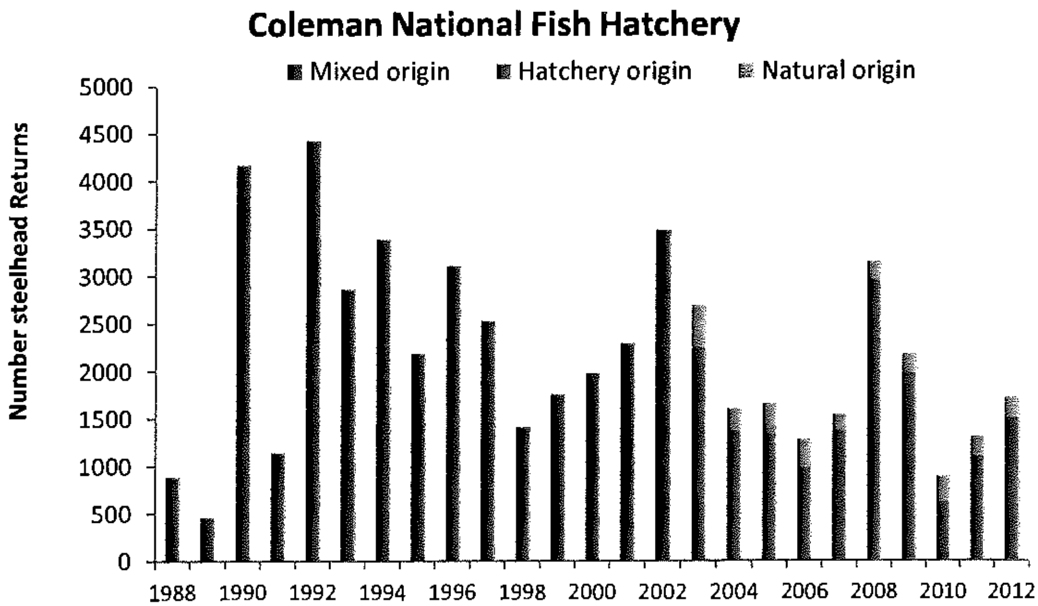

Figure 12. Annual steelhead returns to Coleman NFH. Adipose fin-clipping of hatchery smolts started in 1998 and since 2003 all returns have been categorized either natural or hatchery origin.

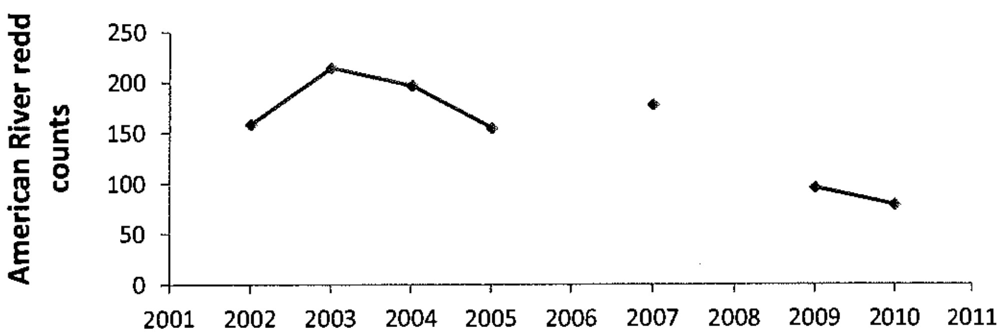

Figure 13. American River steelhead redd counts from Reclamation surveys 2002–2010. Surveys could not be conducted in some years due to high flows and low visibility.

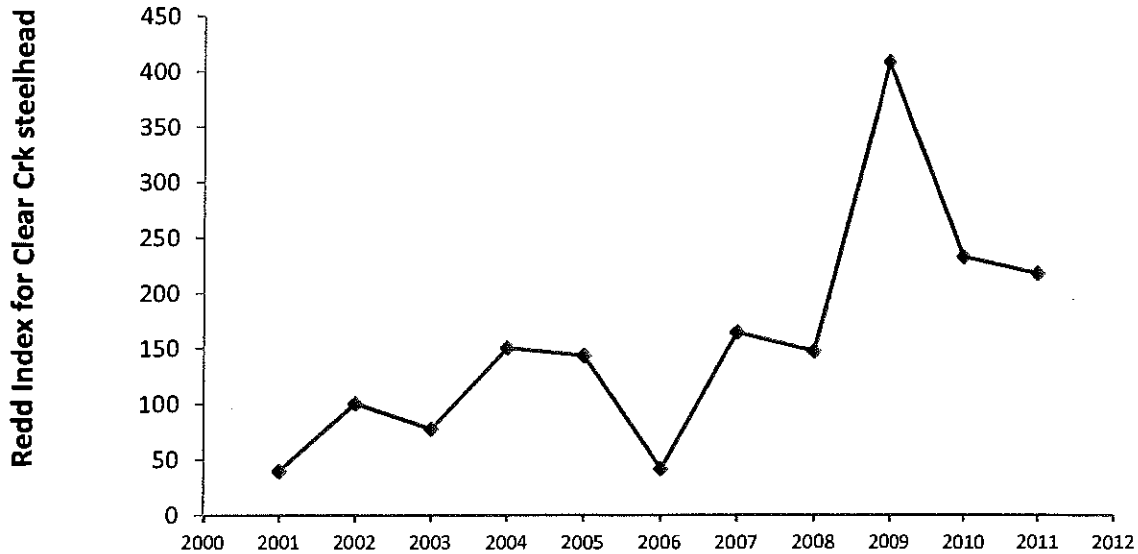

Figure 14. Clear Creek steelhead redd counts from USFWS surveys 2001–2011.

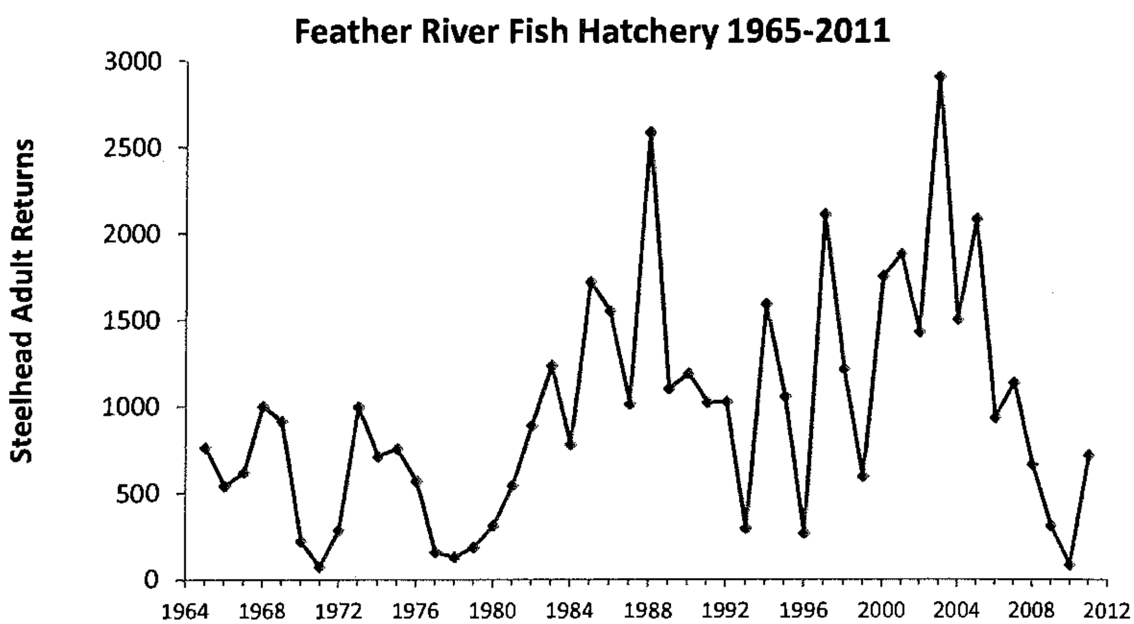

Figure 15. Feather River Fish Hatchery steelhead returns 1965–2011. Almost all fish are hatchery origin.

2. Productivity

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest

that the productivity of CCV steelhead in the San Joaquin Basin is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams *et al.* 2011).

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

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

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

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural steelhead production has continued to decline, and that hatchery origin fish represent an increasing proportion of the juvenile production in the Central Valley. Beginning in 1998, all hatchery produced steelhead in the Central Valley have been marked (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. The proportion of hatchery fish exceeded 90 percent in 2007, 2010, and 2011 (Figure 16). Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley.

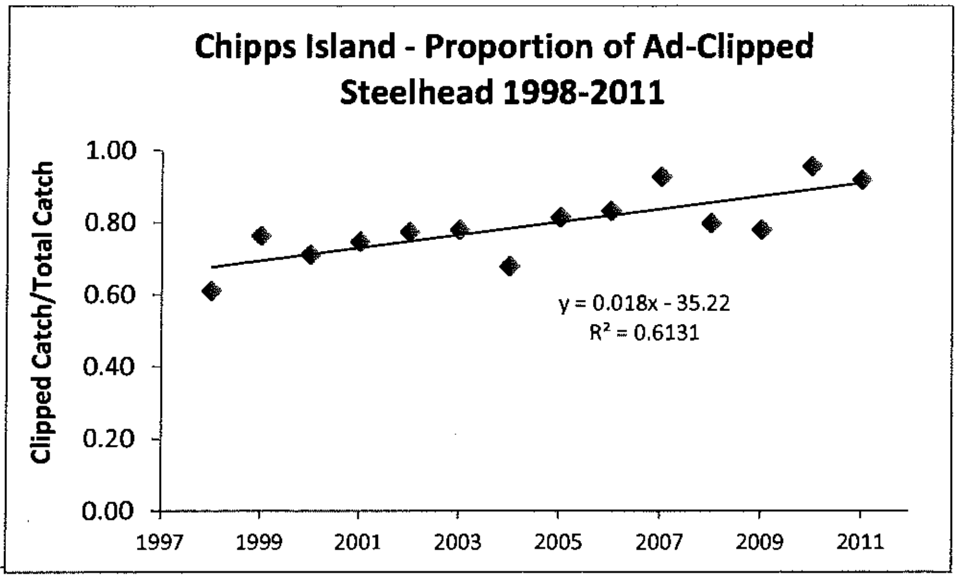

Figure 16. Catch of steelhead at Chipps Island in the USFWS midwater trawl survey 1998–2011. Fraction of the catch bearing an adipose fin clip. All hatchery steelhead have been marked starting in 1998.

Salvage of juvenile steelhead at the CVP/SWP fish collection facilities also indicates a reduction in the natural production (percent wild) of steelhead has occurred since the early 1990s (Figure 17). The percentage of non-clipped juvenile steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (NMFS 2011b).

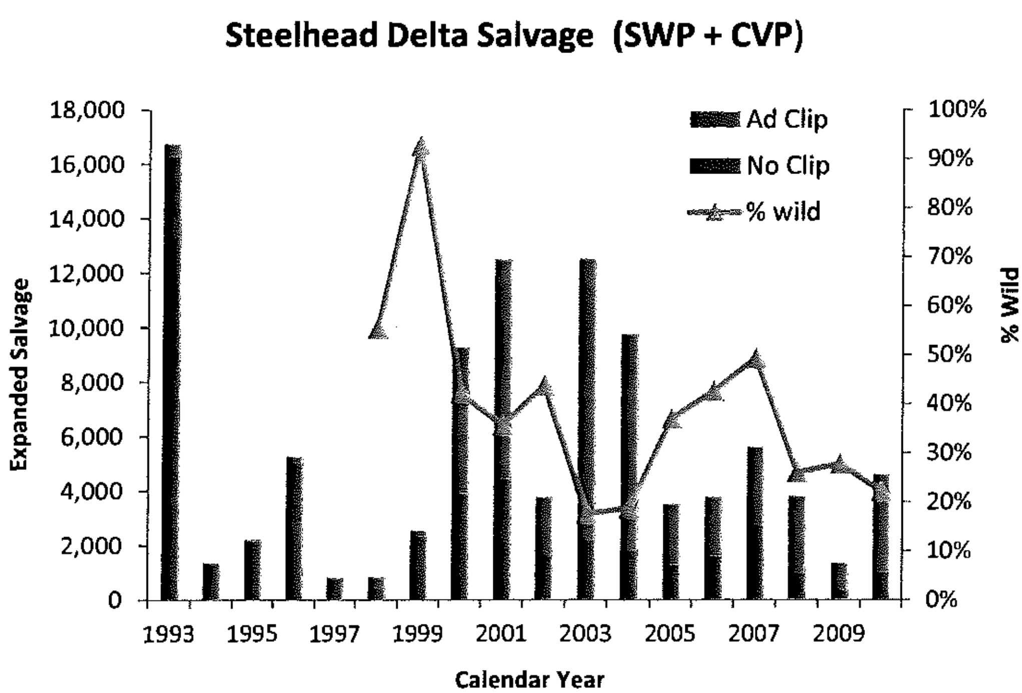

Figure 17. Steelhead salvaged in the Delta fish collection facilities from 1993 to 2010. All hatchery steelhead have been adipose fin-clipped since 1998 (ftp.delta.dfg.ca.gov/salvage).

In contrast to the data from Chipps Island and the CVP/SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (*e.g.*, Clear Creek) while others (*e.g.*, Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011b). Since 2003, fish returning to the Coleman NFH have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year.

3. Spatial Structure

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

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005; NMFS 2011b). Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in RSTs each year since 1995 (FishBio 2012). A counting weir has been in place in the Stanislaus River since 2002, and in the Tuolumne River since 2009, to detect adult salmon; these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FishBio 2012, 2013a). In addition, RST sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FishBio 2013b). RSTs are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in RSTs on the Merced River until 2012, when a total of 381 were caught (FishBio 2013c). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24 hour period. On the San Joaquin River annual Kodiak trawl surveys are conducted at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS (NMFS 2014).

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for spring-run could also benefit CCV steelhead (NMFS 2011b).

4. <u>Diversity</u>

a. Genetic Diversity: CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley *et al.* 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

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

b. Life-History Diversity: Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning.

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

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

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

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

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

5. Summary of ESU Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005; NMFS 2011b); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and two of the four hatcheries are dominated by stock originating from outside the Central Valley.

A continued decline in the ratio between naturally produced and hatchery produced juvenile steelhead indicates that the wild population fitness and abundance is declining. Hatchery releases since marking began have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

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

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as drought and climate change (NMFS 2011b). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

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

2.2.4 Southern DPS of North American Green Sturgeon

A. Species Listing and Critical Habitat

- listed as threatened April 7, 2006 (71 FR 17757)
- designated critical habitat on October 9, 2009 (74 FR 52300)

B. Species Listing and Critical Habitat History

Two distinct population segments (DPSs) of North American green sturgeon have been identified; a northern DPS (nDPS) and a southern DPS (sDPS). While individuals from the two DPS's are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed or utilize the same natal streams. This document will focus on sDPS green sturgeon and its critical habitat as it is listed under the ESA. The sDPS green sturgeon include those that spawn south of the Eel River, specifically within the Sacramento River, Feather River, and possibly the Yuba River. In this document we review the life history of sDPS green sturgeon, discuss population viability parameters, identify extinction risk, discuss critical habitat features and their conservation values, and we discuss the suite of factors affecting the species. When necessary to fill in knowledge gaps, we use available life history information for white sturgeon (*Acipenser transmontanus*) and other sturgeon species, noting the use of other species life history information as a surrogate.

In June of 2001, NMFS received a petition to list green sturgeon and designate their critical habitat under the ESA. After completion of a status review (Adams et al. 2002), NMFS found that the species was comprised of two DPS's that qualify as species under the ESA, but that neither DPS warranted listing. In 2003, this decision was challenged in federal court and NMFS was asked to reconsider available life history information. In April of 2005, NMFS revised its "not warranted" decision and proposed to list the sDPS as "threatened" (71 FR 17757). In 2006, in its final decision to list sDPS green sturgeon as threatened, NMFS cited the presence of the only known spawning population limited to a single river (Sacramento River), in California's Central Valley. It also cites the loss of historical spawning habitat, mounting threats regarding habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based on salvage data from the State and Federal salvage facilities (71 FR 17757).

Since the original 2006 listing decision, new information has become available, reaffirming NMFS concerns that sDPS green sturgeon face substantial threats to their viability and recovery (Israel and Klimley 2008). Information concerning the status was obtained from various literature sources, NMFS' 5-year status reviews (NMFS 2005, 2015), and the draft Green Sturgeon Recovery Plan (NMFS 2010).

C. Critical Habitat Physical and Biological Features (PBF) for sDPS green sturgeon

NMFS designated critical habitat for sDPS green sturgeon on October 9, 2009, under Section 4(b) of the ESA (74 FR 52300). Out of 41 habitat units considered for designation, 14 units were excluded. It was found that the economic benefit of exclusion outweighed the conservation benefits of designation and these exclusions would not significantly impede the conservation of the species. Critical habitat for sDPS green sturgeon includes, (1) the Sacramento River from the I-Street Bridge to Keswick Dam, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge (2) the Feather River up to the Fish Barrier Dam, (3) the Yuba River up to Daguerre Point Dam (4) the Sacramento-San Joaquin Delta (as defined by California Water Code section 12220), but with many exclusions (see 74 FR 52300), (5) San Francisco Bay, San Pablo Bay, and Suisun Bay, but with many exclusions, and (6) coastal marine areas to the 60 fathom depth bathymetry line, from Monterey Bay, California to the Strait of Juan de Fuca, Washington (Figure 18).

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

Critical habitat for sDPS green sturgeon is defined as specific areas that contain the primary PBFs essential to the conservation of the species. The following are PBFs designated for sDPS green sturgeon found in the freshwater and estuarine systems of the Central Valley (74 FR 52300).

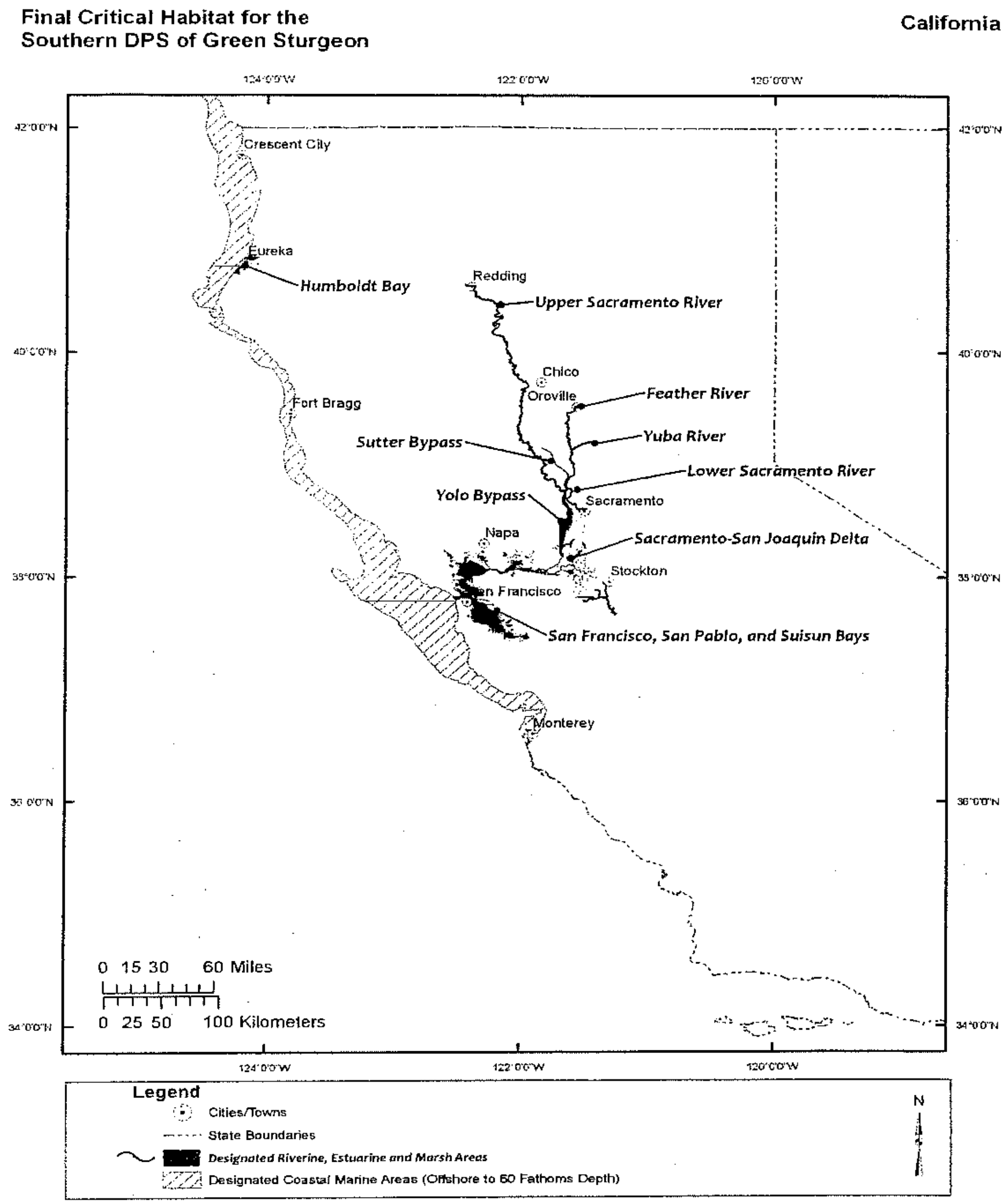

Figure 18. Green sturgeon critical habitat in California (Source: 74 FR 52300).

The specific PBFs in freshwater riverine systems include:

1. Food Resources

Green sturgeon food resources likely include drifting and benthic invertebrates, forage fish, and fish eggs. In a stomach content analysis, Radtke (1966) found that the diet of juvenile green sturgeon consisted primarily of Mysid shrimp (*Neomysis awatschensis*) and Amphipods (*Corophium*). Although little specific information on food resources is available for green sturgeon at various lifecycle stages within freshwater riverine systems, they are presumed to be opportunistic feeders with a diet similar to other sturgeon such as white sturgeon which also occupy the Sacramento River basin (Israel and Klimley 2008). Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items for white sturgeon in the lower Columbia River (Muir *et al.* 2000). Increasing size of prey items in white sturgeon has also been positively correlated with increasing sizes of individual fish (Muir *et al.* 2000).

2. Substrate Type or Size

Green sturgeon eggs are found in pockets of sand and gravel (2.0–64.0 mm in size) and in the interstitial spaces of larger substrate, such as cobble and boulders (Poytress *et al.* 2011). Eggs are likely to adhere to sand and gravel after settling into spaces between larger substrates (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Larvae utilize benthic structure (Van Eenennaam et al. 2001, Deng *et al.* 2002, Kynard *et al.* 2005) and seek refuge within crevices, but will forage over hard surfaces (Nguyen and Crocker 2006).

3. Water Flow

Sufficient flow is necessary to reduce the incidence of fungal infestations of eggs, to flush fine material from feeding and rearing substrates and to facilitate access to spawning grounds for spawning adults. 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. The majority of adult outmigration is thought to occur in the fall months when flows increase. Heublein *et al.* (2009) found that some tagged individuals out-migrated in the fall and timing was correlated with the first winter pulse flow. However, others out-migrated in the late summer in which no known flow or temperature-related cues could be correlated. nDPS green sturgeon have exhibited similar behavior. In the Rogue River, adult green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 50°F (10°C) and flows increased (Erickson *et al.* 2002). On the Klamath River, the fall outmigration of 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).

4. 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, salinities, and dissolved oxygen levels are discussed in detail in the life history section.

5. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to access spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats in freshwater rivers to estuarine rearing habitats. This PBF is highly degraded compared to its historical condition due to man-made barriers and alteration of habitat. The Anderson-Cottonwood Irrigation District (ACID) Dam, at river mile (RM) 297, forms a barrier to any potential sturgeon migration. Downstream of this point, good spawning and rearing habitat exists, primarily in the river reach between Keswick Dam and RBDD (RM 242). The Feather River and Yuba River also offer potential green sturgeon spawning habitat, but those rivers contain their own man-made barriers to migration and are highly altered environments.

6. Water Depth

Deep pools (> 5m depth) are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon have been observed in deep pools above the Glen Colusa Irrigation District (GCID) diversion in the Sacramento River. The significance and purpose of these aggregations are unknown, but may be a behavioral characteristic of green sturgeon occurring elsewhere in the Delta and Sacramento River. Approximately 54 pools with adequate depth have been identified in the Sacramento River above the GCID location (Thomas *et al.* 2013). 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).

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 (*e.g.*, mercury, copper, zinc, cadmium, and chromium); selenium; polycyclic aromatic hydrocarbons (PAHs); and organochlorine pesticides] that can result in negative effects on any life stage of green sturgeon and/or their prey. Metals have been shown to bio-accumulate in Acipenserids (taxonomic family containing green sturgeon), although less is known about its effects on their behavior at any given life stage (Kruse and Scarnecchia 2002). PAHs found in oil-based products are known to bio-accumulate in fish and have carcinogenic, mutagenic and cytotoxic effects (Johnson *et al.* 2002).

The specific PBFs in estuarine areas include:

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. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within bays and estuaries.

2. Water Flow

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin 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. Nakamoto *et al.* (1995) found that juvenile growth in green sturgeon is associated with downstream migration. Adequate flows are also likely required to facilitate downstream migratory behavior in juveniles.

3. Water Quality

Adequate water quality, including temperature, salinity, dissolved oxygen content, and other physical/chemical characteristics, is necessary to sustain normal behavior, growth and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen necessary for green sturgeon are discussed in detail in the life history section.

4. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for the successful and timely passage of adult, sub-adult, and juvenile fish within estuarine habitats and between estuarine and riverine or marine habitats. sDPS green sturgeon are known to use the Sacramento River and the Sacramento-San Joaquin Delta as a migratory corridor. Additionally, certain bays and estuaries throughout Oregon and Washington and into Canada are utilized for rearing and holding, and these areas must also offer safe and unobstructed migratory corridors (Lindley *et al.* 2011).

Two key areas of concern are the Yolo and Sutter bypasses. These leveed floodplains are engineered to convey floodwaters of the greater Sacramento Valley and they include concrete weir structures (Fremont and Tisdale Weirs) that allow flood flows to escape into the bypass channels. Adult sturgeon are attracted to the bypasses by these high flows. However, the weirs can act as barriers, impeding fish passage. Fish can also be trapped in the bypasses as floodwaters recede (USFWS 1995, DWR 2005). Some of the weir structures include fish ladders intended to provide upstream passage for adult salmon but have shown to be ineffective for providing upstream passage for adult sturgeon (DWR and Reclamation 2012). In addition, there are irregularities in the splash basins at the foot of these weirs and multiple road crossings and agricultural impoundments in the bypasses that block hydraulic connectivity, further impeding fish passage. As a result, sturgeon may become stranded in the bypasses, delaying migration. They also may face lethal and sub-lethal effects from poaching, high water temperatures, low dissolved oxygen, and desiccation.

5. Water Depth

Habitat complexity is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy deep (more than 15 feet) 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 30 feet, 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).

6. Sediment Quality

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

PBFs for Coastal Marine Areas

The PBFs for coastal marine areas are omitted from this document as it is focused on the California Central Valley and the Sacramento-San Joaquin Bay Delta. A full description of all PBFs, including those for coastal marine areas, may be found in (74 FR 52300).

C. Green Sturgeon Life History

1. General Information

Green sturgeon belong to the family Acipenseridae, an ancient lineage of fish with a fossil record dating back approximately 200 million years. They are known to be long lived; green sturgeon captured in Oregon have been aged up to 52 years old, using a fin-spine analysis (Farr and Kern 2005). Green sturgeon are highly adapted to benthic environments, spending the majority of their lifespan residing in bays, estuaries, and near coastal marine environments. They are anadromous, migrating into freshwater riverine habitats to spawn; and iteroparous as individuals are able to spawn multiple times throughout their lifespan. Further details of their life history can be found in various literature sources such as Moyle (2002), Adams *et al.* (2007), Beamesderfer *et al.* (2007), and Israel and Klimley (2008). A general timeline of green sturgeon development is provided in Table 5. There is considerable variability across categories, such as size or age at maturity.

2. Adult Migration and Spawning

Green sturgeon reach sexual maturity between 15–17 years of age (Beamesderfer *et al.* 2007), and they typically spawn once every 2–5 years (average is 3.75 years) (Mora unpublished data). Based on data from acoustic tags (Heublein *et al.* 2009), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between January and early May. Migration through the bay/Delta takes about one week and progress upstream is fairly rapid to their spawning sites (Heublein *et al.* 2009). The majority of adult green sturgeon abundance occurs in the Sacramento River, suggesting that the majority of spawning activity occurs there as well. In a recent survey, three observed sites on the Sacramento River accounted for over 50 percent of observed green sturgeon spawning (Mora unpublished data). However, in 2011, spawning was confirmed in the Feather River by DWR, and suggested in the Yuba River (Bergman *et al.* 2011). Spawning activity is concentrated in the mid-April to mid-June time period (Poytress *et al.* 2013).

Table 5. Green sturgeon life history including length-life stage information in bold.

Timeline	Life stage, Length-age relationship
Fertilization of eggs	Spawning occurs primarily in deep water (> 5m) pools[1] at very few select sites[2], predominantly in the Sacramento River, predominantly in time period mid-April to mid-June[3]
144 – 192 hours (6-8 days) to hatch	Newly hatched larvae emerge from gravel. **Larvae are 12.6 – 14.5 mm** in length[4]
6 days post hatch (dph)	Larvae, nocturnal swim up, hide by day behavior observed[4]
10 dph	Larvae begin exogenous feeding between 10-15 dph[4]. Larvae begin to disperse downstream
2 weeks old	Larvae appear in rotary screw traps at the RBDD at lengths of 24 to 31 mm.
45 dph	Larval to juvenile metamorphosis complete. Begin juvenile life stage. **Juveniles are 63 – 94 mm** in length.
45 days to 1.5 years	Juveniles migrate downstream and into the Delta or the estuary and rear to the sub-adult phase. **Juveniles range in size from around 70 mm to 90 cm.** Little information available about this life stage.
1.5 – 4 years	Juveniles migrate from Delta to ocean, thereby entering the sub-adult phase. **Subadults are 91cm to 149 cm.**
1.5 years to 15–17 years	Subadults enter the ocean where they grow and develop, reaching maturity between 15–17 years of age*
15–17 years*	Adults in ocean reach sexual maturity, **males mature around 120 cm, females mature around 145 cm**[5]
15 years to 50+ years	Adult lifespan up to 50 or more years, mostly marine, and can grow to a **total length of over 2 meters**

Sources: 1. Thomas *et al.* (2013), 2. Mora, unpublished data, 3. Poytress *et al.* (2013), 4. Deng *et al.* (2002) 5. Nakamoto *et al.* (1995)
*green sturgeon in the Klamath River might reach sexual maturity as early as 13 years for females and 9 years for males.

Various studies of spawning site characteristics (Poytress *et al.* 2011, Thomas *et al.* 2013, Thomas *et al.* 2013, and Mora unpublished data) agree that spawning sDPS green sturgeon typically favor deep, turbulent holes over 5 meters deep, featuring sandy, gravel, and cobble type substrates. However, spawning depth may be variable, as spawning has been documented in depths as shallow as 2 meters (Poytress *et al.* 2011). Substrate type is likely constrained as the interstices of the cobble and gravel catch and hold eggs, allowing them to incubate without being washed downstream. Under laboratory conditions, green sturgeon larvae (0-15 dph) have shown to utilize cobble and gravel for shelter, even after commencing exogenous feeding (Kynard *et al.* 2005). Adequate flows are required to create the deep, turbulent habitat that green sturgeon favor for spawning. Successful egg development requires a water temperature range between 51.8°–66.2°F (11°C–19°C). As larvae and juveniles mature, their range of temperature tolerance increases.

Green sturgeon fecundity is approximately 50,000–80,000 eggs per adult female (Van Eenennaam et al. 2001), and they have the largest egg size of any sturgeon. The outside of the eggs are mildly adhesive, and are denser than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009).

Poytress *et al.* (2012) conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 that identified a number of spawning locations (Figure 19). After spawning, adults have been observed to leave the system rapidly, or hold in deep pools and migrate downriver after the first storms of winter. Benson *et al.* (2007) conducted a study in which 49 adult green sturgeon were tagged with radio and/or sonic telemetry tags and tracked manually or with receiver arrays from 2002 to 2004. Tagged individuals exhibited four movement patterns: 1) upstream spawning migration, 2) spring outmigration to the ocean, 3) summer holding, and 4) outmigration after summer holding. Adult green sturgeon that hold over the summer typically re-enter the ocean from November through January (Lindley *et al.* 2008), however, Benson *et al.* (2007) also observed outmigration to the ocean in the spring.

3. Juvenile Migration

Larval green sturgeon hatch in the late spring or summer (peak in July) and presumably progress downstream towards the Delta as they develop into juveniles. It is uncertain when juvenile green sturgeon enter the Delta or how long they rear before entering the ocean. Ocean entry marks the transition from juvenile to sub-adults.

4. Egg and Larval Stages

Green sturgeon larvae have been observed hatching from fertilized eggs after approximately 169 hours at a water temperature of 15°C (59° F) (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Studies conducted at the University of California, Davis (UC Davis) by Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14°C (57.2°F) and 17.5°C (62.6°F). Eggs incubated at water temperatures between 17.5°C (63.5°F) and 22°C (71.6°F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch (Van Eenennaam *et al.* 2005). Temperatures over 23°C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching (Van Eenennaam *et al.* 2005). Further research is needed to identify the lower temperature limits for eggs and larvae.

Information about the life history and behavior of larval sDPS green sturgeon in the wild is very limited. USFWS conducts annual sampling for eggs and larvae in the mainstem Sacramento River. Larval green sturgeon appear in USFWS rotary screw traps at the RBDD from May through August (Poytress *et al.* 2010) at lengths ranging from 24 to 31 mm (FL), indicating they are approximately two weeks old (CDFG 2002, USFWS 2002). These data provide limited information about green sturgeon larvae including time and date of capture, and corresponding river conditions such as temperature and flow parameters.

Little is known about diet, distribution and outmigration timing of larvae. Laboratory studies have provided some information about larval behavior, but the relevance to in-situ behavior is unknown.

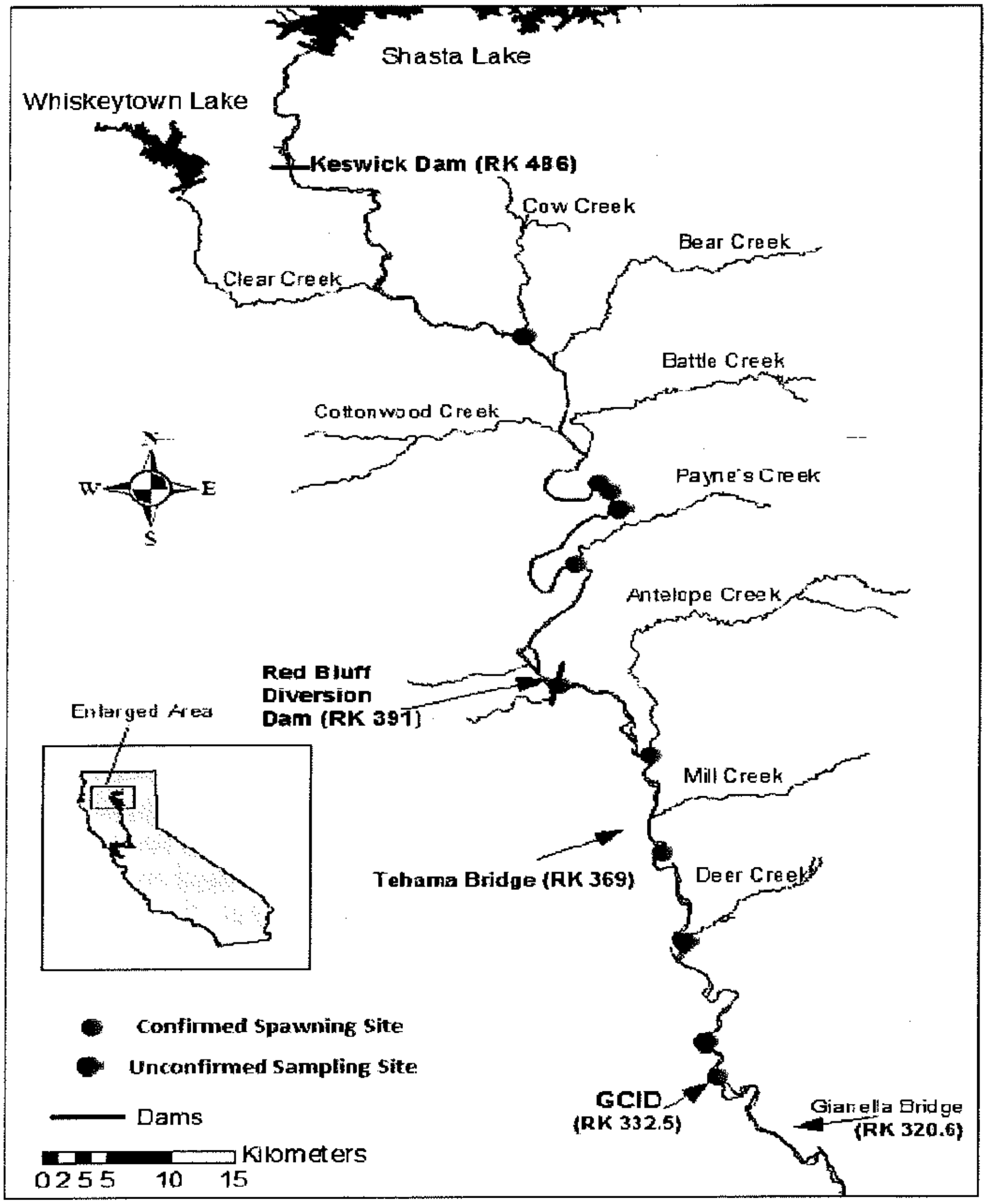

Figure 19. Green sturgeon spawning locations in the Sacramento River 2008–2012. Source: Poytress *et al.* (2012). Unconfirmed sites indicate an area where sturgeon have been known to congregate but where evidence of spawning was not obtained in the study.

5. Juvenile Development and Outmigration

Juvenile green sturgeon are defined as individuals that have completed metamorphosis or are greater than 45 dph according to Deng *et al.* (2002). They appear to spend their first one to two months rearing in the Sacramento River (CDFG 2002). Little is known about juvenile growth rates in the sDPS. USWFS has sampled juvenile green sturgeon in the mainstem Sacramento River and found that some individuals reach approximately 300 mm total length in 6 months (Poytress, USFWS, unpublished data). The lack of any records of juveniles smaller than approximately 200 mm in the Delta may suggest rearing upstream in the Sacramento River, or its tributaries. Juvenile sDPS green sturgeon may hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard *et al.* (2005). Juvenile green sturgeon captured in the Delta by Radtke (1966) ranged in size from 200-580 mm, further supporting the hypothesis that juvenile green sturgeon enter the Delta after 10 months or when they are greater than 200 mm in size.

Radtke (1966) inspected the stomach contents of juvenile green sturgeon (range: 200-580 mm) in the Delta and found food items to include mysid shrimp (*Neomysis awatschensis)*, amphipods (*Corophium sp.)*, and other unidentified shrimp. In the northern estuaries of Willapa Bay, Grays Harbor, and the Columbia River, green sturgeon have been found to feed on a diet consisting primarily of benthic prey and fish common to the estuary. For example, burrowing thalassinid shrimp (mostly *Neotrypaea californiensis*) were important food items for green sturgeon taken in Willapa Bay, Washington (Dumbauld *et al.* 2008).

6. Estuarine Rearing

The age of first ocean entry in sDPS green sturgeon is poorly understood. Juvenile green sturgeon in the nDPS may spend 2 to 3 years in fresh or brackish water before making their first migration to sea. Nakamoto *et al.* (1995) found that on average, green sturgeon on the Klamath River migrated to sea by age three and no later than age four. On the Klamath River (nDPS), Allen *et al.* (2009) devised a technique to estimate the timing of transition from fresh water to seawater by taking a bone sample from the leading edge of the pectoral fin and analyzing the strontium/calcium ratios. The results of this study indicate that nDPS green sturgeon move from freshwater to brackish water at 0.5–1.5 years of age and then move into seawater at 2.5-3.5 years of age. Moyle (2002) suggests that sDPS green sturgeon migrate out to sea before the end of their second year, and perhaps as young of the year (YOY). Laboratory experiments indicate that green sturgeon juveniles may occupy fresh to brackish water at any age, but they gain the physiological ability to transition to saltwater at approximately 1.5 years of age (Allen and Cech 2007). Juvenile sDPS green sturgeon in the Delta have been salvaged at the Federal and State pumping facilities and collected in sampling studies by CDFW during all months of the year (CDFG 2002). Fish salvage data from 1981–2016 show that the majority of juveniles were between 200 and 500 mm (Figure 20). Very few juvenile green sturgeon have been sampled at the salvage facilities in the last ten years (2006-2016) with only one reported in 2016.

7. Ocean Rearing

Once green sturgeon juveniles make their first entry into sea, they enter the sub-adult phase and spend multiple years migrating along the coastal zones, bays, and estuaries (Lindley *et al.* 2008). Sub-adult green sturgeon have not been observed in freshwater spawning areas. Green sturgeon mature at approximately 15 to 20 years of age and an individual may spawn once every 2–4 years and live for 50 years or more (Moyle 2002, Israel and Klimley 2008).

In the summer months, multiple rivers and estuaries throughout the sDPS range are visited by dense aggregations of adult green sturgeon (Moser and Lindley 2007, Lindley *et al.* 2011). Genetic studies on green sturgeon stocks indicate that the green sturgeon in the San Francisco Bay ecosystem belong exclusively to the sDPS (Israel *et al.* 2009). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly *et al.* 2007, Heublein *et al.* 2009, Lindley *et al.* 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean (Huff *et al.* 2011), and why they aggregate episodically (Lindley *et al.* 2008, and 2011).

D. Green Sturgeon Viable Salmonid Population Parameters

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a viable salmonid population (VSP). The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and to ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany *et al.* 2000). The VSP concept measures population performance in terms of four key parameters: abundance, population growth rate, spatial structure, and diversity. Although the VSP concept was developed for Pacific salmonids, the underlying parameters are general principles of conservation biology and can therefore be applied more broadly. Here, we adopt the VSP parameters for analyzing sDPS green sturgeon viability.

1. Abundance

Trends in abundance of sDPS green sturgeon have been estimated from two long-term data sources; (1) salvage numbers at the State and Federal pumping facilities (see below), (2) by incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Historical estimates from these sources are likely unreliable as sDPS was likely not taken into account in incidental catch data and salvage does not capture range-wide abundance in all water year types. Recently, more rigorous scientific inquiry has been undertaken to generate abundance estimates (Israel and May 2010; Mora unpublished data).

A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the SWP/CVP Fish Salvage Facilities. This data should be interpreted with some caution since: a) counts are expanded for time, b) operations and practices at the facilities have changed, and c) conditions in the south Delta have changed. The salvage data likely indicate a high production year vs. a low production year qualitatively, but cannot be used to rigorously quantify abundance. However, despite the potential pitfalls of using salvage data to estimate trends in abundance for sDPS green sturgeon, the historical trend indicates a steep decline in abundance (Figure 20).

Since 2010, more robust estimates of sDPS green sturgeon have been generated. As part of a doctoral thesis at UC Davis, Ethan Mora has been using acoustic telemetry to locate green sturgeon in the Sacramento River, and to derive an adult spawner abundance estimate. Preliminary results of these surveys estimate an average annual spawning run of 272 fish (Mora unpublished data). This estimate does not include the number of spawning adults in the lower Feather or Yuba Rivers, where green sturgeon spawning was recently confirmed (Seesholtz *et al.* 2015).

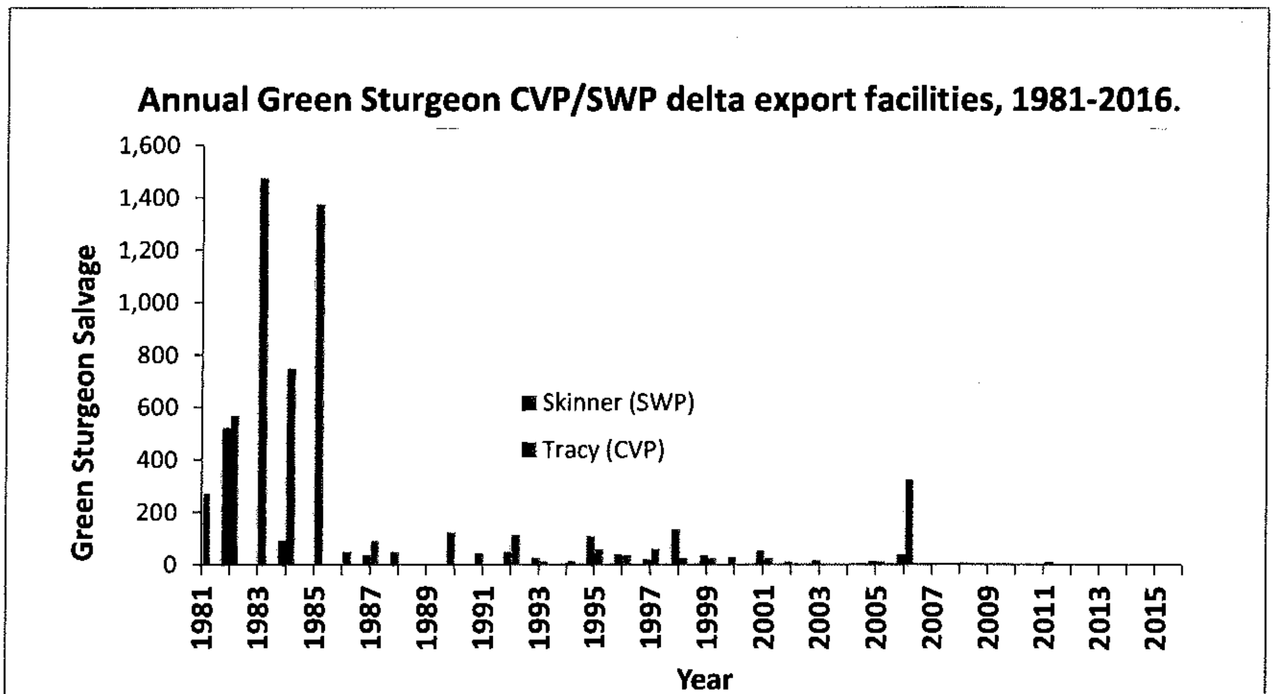

Figure 20. Annual salvage of green sturgeon for the State and Federal salvage facilities 1981–2016. Salvage estimated from October-June. Data source: ftp://ftp.delta.dfg.ca.gov/salvage

2. Productivity

The parameters of green sturgeon population growth rate and carrying capacity in the Sacramento Basin are poorly understood. Larval count data are available from RSTs set seasonally near Red Bluff and Glen Colusa irrigation diversions. This data shows enormous variance among years with the greatest number of larval green sturgeon occurring in 2011 when 3,700 larvae were captured (Poytress *et al.* 2012). In other years, larval counts were an order of magnitude lower. In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events (NMFS 2010b). Other indicators of productivity such as data for cohort replacement ratios and spawner abundance trends are not currently available for sDPS green sturgeon. The long lifespan of the species and long age to maturity makes trend detection dependent upon data sets spanning decades. The acoustic telemetry work begun by Ethan Mora (UC Davis) on the Sacramento River and by Alicia Seesholtz (CDWR) on the Feather River, as well as larval and juvenile studies by Bill Poytress (USFWS), may eventually produce a more statistically robust analysis of productivity.

3. Spatial Structure

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During late summer and early fall, subadults and non-spawning adult green sturgeon can frequently be found aggregating in estuaries along the Pacific coast (Emmett 1991, Moser and Lindley 2007). Using polyploid microsatellite data, Israel *et al.* (2009) found that green sturgeon within the Central Valley of California belong to the sDPS. Additionally, acoustic tagging studies have found that green sturgeon found spawning within the Sacramento River are exclusively sDPS green sturgeon (Lindley *et al.* 2011).

In waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and the Delta and up the Sacramento, Feather, and Yuba rivers. The minimum northern-most extent of this range is thought to be Cow Creek (Mora, unpublished data). In the Yuba River, green sturgeon have been documented up to Daguerre Point Dam (Bergman *et al.* 2011) which currently impedes access to areas upriver. Similarly, in the Feather River, green sturgeon have been observed by CDWR staff up to the Fish Barrier Dam. On the Sacramento River, the ACID dam at RM 297 is thought to be the highest point on the river accessible to green sturgeon. Viable spawning habitat may exist up to this point. Adult green sturgeon were detected up the confluence with Cow Creek in 2005 and spawning was confirmed at the confluence with Ink's Creek in 2011 (Heublein *et al.* 2009; Poytress *et al.* 2012). Adams *et al.* (2007) summarizes information that suggests green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers. Mora *et al.* (2009) analyzed and characterized known green sturgeon habitat and used that characterization to identify potential green sturgeon habitat within the Sacramento and San Joaquin River basins that now lies behind impassable dams. This study concludes that approximately 9 percent of historically available habitat is now blocked by impassible dams. It is likely that this blocked habitat was of high quality for spawning.

Studies conducted at UC Davis (Mora unpublished data) have shown that green sturgeon spawning sites are concentrated in just a handful of locations. Mora (unpublished data) found that in the Sacramento River, just 3 sites accounted for over 50 percent of the green sturgeon documented in June of 2010, 2011, and 2012. This finding has important implications for the application of the spatial structure VSP parameter, which is largely concerned with spatial structuring of spawning habitat. Given the high density of individuals within a few spawning sites, extinction risk due to stochastic events is expected to have increased since the onset of dam construction and habitat loss in Central and Northern California.

Green sturgeon have been historically captured and are regularly detected within the Delta area of the lower San Joaquin River. Anglers have reported catching a small number of green sturgeon at various locations in the San Joaquin River upriver of the Delta. However, there is no known modern usage of the upper San Joaquin River and adult green sturgeon spawning has not been documented. Based on this information, it is unlikely that green sturgeon utilize areas of the San Joaquin River upriver of the Delta with regularity and spawning events are thought to be limited to the upper Sacramento River and its tributaries.

Recent research indicates that the sDPS is composed of a single, independent population, which principally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and possibly even the Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent, but unconfirmed extirpation of spawning populations from the San Joaquin River narrows the available habitat within their range, offering fewer habitat alternatives.

4. Diversity

Diversity, as defined in the VSP concept in (McElhany *et al.* 2000), includes purely genetically-driven traits such as DNA sequence variation, as well as traits that are driven by a combination of genetics and the environment such as ocean behavior, age at maturity, and fecundity. Variation is important to the viability of a species for several reasons. First, it allows a species to utilize a wide array of environments. Second, diversity protects a species from short term spatial and temporal changes in the environment by increasing the likelihood that at least some individuals will persist in spite of changing environmental conditions. Third, genetic diversity facilitates adaptation to changing environmental conditions over the long term.

Whether sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long term extinction risk is not well understood. It is likely that the diversity of sDPS green sturgeon is low, given recent abundance estimates. Human alteration of the environment is pervasive in the California Central Valley. As a result, many aspects of sDPS green sturgeon diversity such as run timing and behavior have likely been adversely influenced through mechanisms such as altered flow and temperature regimes.

5. Summary

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

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 (NMFS 2010a). 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 2010a). 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 has not been designated as viable.

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.* (2008), 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 a large timescale. This concern applies to any DPS or ESU represented by a single population, suggesting that sDPS green sturgeon face a high extinction risk in the future. The most recent 5-year status review concluded there was no change in the classification and that some threats, such as those posed by fisheries and impassable barriers, have been reduced (NMFS 2015). Some barriers to upstream passage have been removed on the Sacramento River (RBDD) and Feather River, but the population remains small and subject to the same threats as when they were first listed. Therefore, NMFS determined, upon weighing all available information (and lack of information) that the extinction risk to sDPS green sturgeon is moderate (NMFS 2010a).

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 Project is located in the northeastern-most portion of the San Francisco Bay-Delta Estuary in the Sacramento-San Joaquin Delta, an area commonly referred to as the western Delta. This freshwater to low salinity estuarine habitat provides critical habitat for CCV steelhead and sDPS green sturgeon. The action area is bounded by the Contra Costa Canal (CCC) and pasturelands to the west, Sandmound Slough to the east, Dutch Slough to the north, and Rock Slough to the south. Jersey and Bethel islands are located north of Dutch Slough and the confluence of Dutch Slough and Big Break is just over a mile to the west. The Project is located 4 miles (through Dutch Slough and Big Break) from the San Joaquin River and 1.5 miles from Old River (through Sandmound Slough and Franks Tract). The aquatic habitat in the vicinity of the proposed Project is representative of the estuarine transition zone, where freshwater from the Delta mixes with saline water from estuarine bays to the west.

The principal water bodies near the project area include Dutch Slough, Sandmound Slough, and Rock Slough. Big Break, a large embayment formed when a reclaimed and subsided agricultural "island" flooded after a levee failure in 1928, is located north of the project area and provides connectivity to the San Joaquin River. All of these water bodies are tidally influenced. In the vicinity of the action area, Dutch Slough has water depths between 10 and 20 feet below MSL (DWR 2005). Existing houses and boat docks line both sides of Dutch Slough and the entire west side of Sandmound Slough (Figure 21).

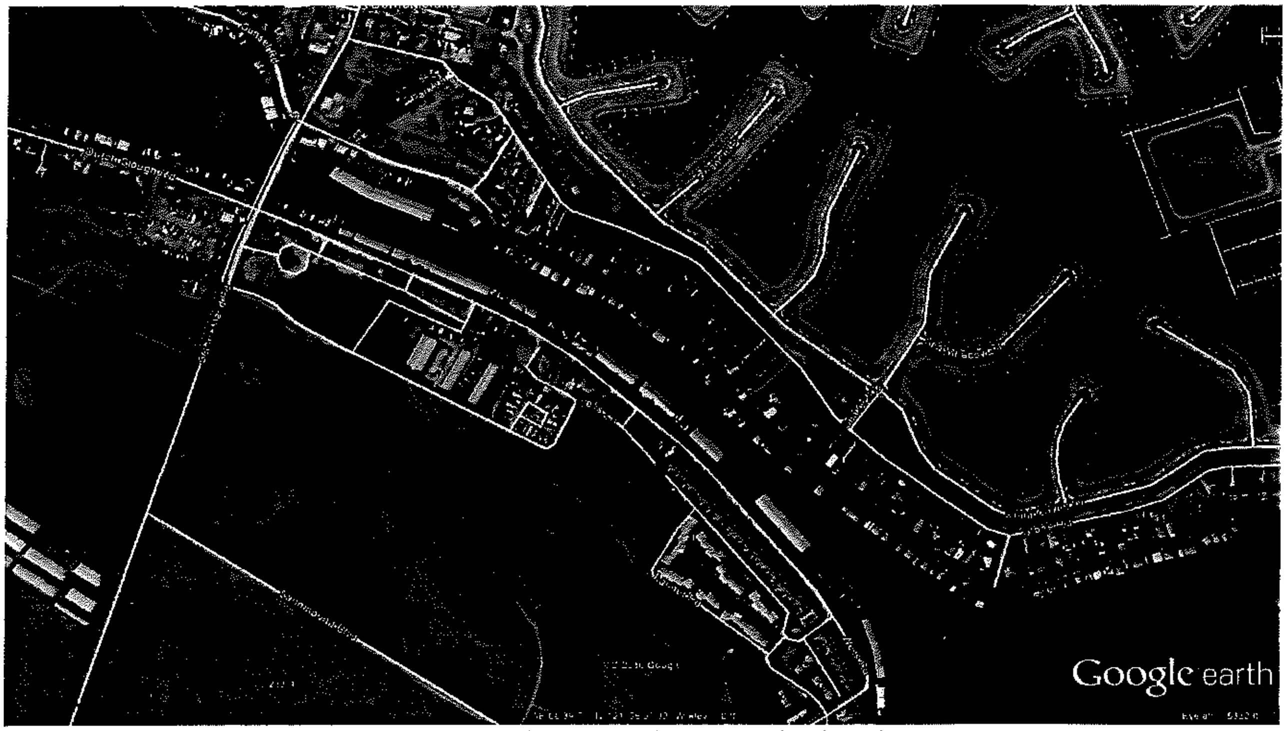

Figure 21. View of existing urban development along Dutch Slough.

Habitats in the action area consist of deep water channels and subtidal and intertidal habitats. Salinities in the action area can range from 0.2 to 0.5 parts per thousand (ppt). The salinity is managed by the State and Federal water projects on the low side (< 0.2 ppt) to prevent salt water from intruding into the Delta and degrading irrigation, as well as municipal water supplies.

Currently, the 1,246.6-acres of land within the Project consist of irrigated fields traversed by irrigation and drainage ditches. Water withdrawals for irrigation are estimated to be 4,400 acre-feet per year. These canals and ditches seasonally flood and drain pastures with Delta water that is either pumped or siphoned from Dutch Slough. Levees are present north, east, and south of the site that separate and protect the site from the waters of the Delta. These existing levees were built in the late 1800s and are maintained for agricultural purposes by RD799. With the exception of the recently constructed levee system associated with the Summer Lake project (residential development), the existing levees do not meet current urban levee standards for engineering and design or the requirements of the Federal Emergency Management Agency.

The central Delta region, where the Project is located, historically supported a healthy aquatic ecosystem, but its habitat value for listed species such as CCV steelhead and sDPS green sturgeon is considered greatly reduced from historic conditions. Several factors are thought to contribute to the decline in the health of the habitat including the potential for direct loss resulting from entrainment into the south Delta SWP and CVP pumping facilities, adverse water quality conditions, and increased predation by nonnative predator species (*e.g.*, striped bass and largemouth bass) (Baxter *et al.* 2007). The increase in the abundance of largemouth bass, as shown by the salvage data at the CVP and SWP pumps, occurred at the same time as the increase in the range of the invasive submerged macrophyte *Egeria densa* (Brown and Michniuk 2007).

Additionally, the central Delta (and portions of the south Delta) had the warmest water and highest water clarity.

In the central Delta region, low-salinity water, invasive aquatic plants (*Egeria densa*), and other factors have resulted in increased numbers of nonnative predators, most important of which are striped bass and largemouth bass. Nobriga and Feyrer (2007) report that largemouth bass have a more limited distribution in the Delta than striped bass, although their impact on prey species, such as juvenile salmonids, is higher. The proliferation of *E. densa* provides habitat for largemouth bass as well as their prey, and its rapid expansion in the Delta increased more than 10% per year from 2004 to 2006 (Baxter *et al.* 2007). Although Chinook salmon fry are often found in the central Delta and make use of the dense stands of *E. densa* for habitat, Brown (2003) found that survival is lower for fry rearing in the central Delta than those rearing in tributary streams. Those fry that migrate through the central Delta rather than directly through the Sacramento or San Joaquin River also have a lower survival rate (Brown 2003). Aside from increasing the habitat area for predators, the large expanse of *E. densa* may have other negative impacts on ESA-listed species. It can overwhelm littoral habitats where salmonids and sDPS green sturgeon rear, and it also appears to contribute to the recent reduction in turbidity of the central and south Delta regions by reducing flow velocity (Brown 2003) and mechanically filtering the water column (Nobriga *et al.* 2005). The resulting increased water clarity has negative effects on juvenile salmonids by increasing their susceptibility to predation.

1. Presence of the Species within the Action Area (August 1–October 15 work window)

The action area is used as a rearing and migration corridor by CCV steelhead and sDPS green sturgeon. Other salmonids (*e.g.*, spring-run Chinook, winter-run Chinook, and fall-run Chinook) are known to occasionally transit the area as they have been observed at the Rock Slough Fish Screen and in monitoring locations north of the proposed Project. These fish are likely straying into the area due to reverse flows caused by the CVP/SWP pumps and Rock Slough diversion (EDAW 2005). Generally, as flows increase in the fall, adult salmon, CCV steelhead, and sDPS sturgeon migrate upstream through Old River and juveniles move downstream in the spring. Adult CCV steelhead migration typically begins in July and extends through the winter to as late as March (Table 4). Adult winter-run typically migrate through the estuary/Delta between November and July with the peak occurring in March (Table 1). Adult spring-run migrate through the Delta between January and August (Table 2).

Adult CCV steelhead returning to the San Joaquin River may use the Dutch Slough route from Big Break to Old River in order to reach their spawning grounds and to return to the ocean. Likewise, juvenile steelhead smolts originating in the San Joaquin River watershed have been observed to pass through the action area during their emigration to the ocean (Reclamation 2016). The waterways in the action area also are expected to provide some rearing benefit to juvenile salmonids, especially juvenile steelhead and juvenile sDPS green sturgeon, as they move through the action area.

a. CCV Steelhead

CCV steelhead occur in both the Sacramento River and the San Joaquin River watersheds, although the spawning population of fish is much greater in the Sacramento River watershed (Good *et al.* 2005). Small, remnant populations of CCV steelhead are known to spawn in tributaries to the San Joaquin River such as the Stanislaus River (Appendix A, Figure 5), Tuolumne River, and their presence is assumed on the Merced River due to proximity, similar habitats, and historical presence. CCV steelhead juveniles (smolts) can start to appear in the action area as early as October, based on the records from the CVP/SWP Fish Salvage Facilities (Table 6). No juvenile steelhead were observed in the CDFW trawl data (2009–2013) from sites north-west of the action area, however, juvenile steelhead were observed in sieve nets behind the Rock Slough Intake before a fish screen was constructed. Juvenile steelhead were observed at the Rock Slough Intake from January through May (Table 11 in Reclamation 2016). One adult steelhead (622 mm) was caught in Rock Slough in November 2009 during a fish rescue prior to building the fish screen (Table 6 in Reclamation 2016), indicating that adult steelhead occasionally utilize this area.

Steelhead presence in CVP/SWP Fish Salvage Facilities (located 11 miles south of the Project) increases from November through January (21.6 percent of average annual salvage) and peaks in February (37.0 percent) and March (31.1 percent) before rapidly declining in April (7.7 percent). By June, emigration essentially ends, with only a small number of fish being salvaged through the summer at the CVP/SWP Fish Salvage Facilities (Appendix A, Figure 6). Kodiak trawls conducted by the USFWS and CDFW on the mainstem of the San Joaquin River downstream of the Mossdale boat ramp (upstream of Stockton) routinely catch low numbers of steelhead smolts from the San Joaquin Basin (CDFW 2013). The RST monitoring on the Stanislaus River at Caswell State Park and further upriver near the City of Oakdale indicate that smolt-sized steelhead start emigrating downstream in January and continue through late May. Fry-sized *O. mykiss* (*i.e.*, 30–50 mm) are captured at the Oakdale RST on the Stanislaus River starting as early as April and continuing through June (FishBio 2012).

b. Winter-run Chinook salmon

Adult winter-run typically tend to migrate upstream on the Sacramento River side of the Delta and, therefore, would not be expected to be in the action area. However, the action area is a transition area between salt and freshwater at the confluence of the Sacramento and San Joaquin rivers. Adult salmon sometimes wander through the Delta searching for specific scents that lead them to their natal spawning area. Winter-run adults have been known to stray into the San Joaquin River and around the islands in the Delta as they make their way through the maze of channels. Winter-run adults could potentially use Dutch Slough to migrate through to Franks Tract. For juvenile winter-run, a detailed review of fish monitoring data from 2009–2013 in and around the action area was provided in (Reclamation 2016). No juvenile winter-run were found in the CDFW data for the 20-mm survey, Summer Townet Survey, Fall midwater Trawl, and during August–October from 2009–2013 (Reclamation 2016). In the CDFW mid-water trawl data from 2009–2013, 16 Chinook salmon were caught; however, these were not identified to race.

In Rock Slough, 32 juvenile Chinook were collected by sieve net from 1999–2011 at the Rock Slough Headworks prior to construction of the fish screen. These were identified by length as 18 fall-run, 11 spring-run, and 3 unknown race (Table 5 in Reclamation 2016).

c. Spring-run Chinook salmon

A review of the CDFW mid-water trawl data for Stations 837 and 853, located 6 miles west of the Project, showed 16 juvenile Chinook salmon were caught from 2009–2013; however, these fish were not identified to run. In Rock Slough, 11 juvenile spring-run Chinook salmon were collected by sieve net at the Rock Slough Headworks from 1999–2011 (prior to construction of the fish screen).

Table 6. Combined monthly salvage data for winter-run, spring-run, and steelhead at the State and Federal Fish Facilities 1999–2009. Steelhead is total hatchery and wild.

Fish Facility Salvage Records (Loss)

Winter Run (loss)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	8	55	210	1654	21	0	0	NA	NA	NA	1948
2007-2008	0	0	0	164	484	628	40	0	0	NA	NA	NA	1316
2006-2007	0	0	87	514	1678	2730	330	0	0	NA	NA	NA	5339
2005-2006	0	0	649	362	1016	1556	249	27	208	NA	NA	NA	4069
2004-2005	0	0	228	3097	1188	644	123	0	0	NA	NA	NA	5280
2003-2004	0	0	84	640	2812	4865	39	30	0	NA	NA	NA	8470
2002-2003	0	0	1261	1614	1464	2789	241	24	8	NA	NA	NA	7401
2001-2002	0	0	1326	478	222	1167	301	0	0	NA	NA	NA	3494
2000-2001	0	0	384	1302	6014	15379	259	0	0	NA	NA	NA	23338
1999-2000	0	0				1592	250	0	0	NA	NA	NA	1842
Sum	0	0	4027	8226	15088	33006	1853	81	216	0	0	0	62497
Avg	0	0	447	914	1676	3301	185	6	22	0	0	0	6553
[illegible]	0.000	0.000	6.828	13.947	25.581	50.364	2.828	0.124	0.330	0.000	0.000	0.000	

Spring-Run (loss)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	0	0	0	333--	5912	2604	4	NA	NA	NA	8853
2007-2008	0	0	0	0	15	315	6918	4573	87	NA	NA	NA	12008
2006-2007	0	0	0	0	7	190	4700	365	0	NA	NA	NA	5262
2005-2006	0	0	0	0	104	1034	8315	3521	668	NA	NA	NA	13642
2004-2005	0	0	0	0	0	1856	10007	1761	639	NA	NA	NA	14263
2003-2004	0	0	0	25	50	4546	5901	960	0	NA	NA	NA	11562
2002-2003	0	0	0	46	57	11400	27977	2577	0	NA	NA	NA	42057
2001-2002	0	0	0	21	8	1245	10832	2465	19	NA	NA	NA	14590
2000-2001	0	0								NA	NA	NA	0
1999-2000										NA	NA	NA	0
Sum	0	0	0	92	241	21019	80562	18926	1417	0	0	0	122257
Avg	0	0	0	12	30	2627	10070	2366	177	0	0	0	15282
% SR/yr	0.000	0.000	0.000	0.075	0.197	17.192	65.896	15.481	1.159	0.000	0.000	0.000	

Steelhead (combined salvage and loss, clipped and non-clipped)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	0	40	571	1355	210	68	13	7	NA	NA	2267
2007-2008	0	0	0	624	4639	717	300	106	24	15	NA	NA	6425
2006-2007	0	0	10	81	1643	4784	2689	113	20	NA	NA	NA	9340
2005-2006	0	0	0	129	867	3942	337	324	619	NA	NA	NA	6218
2004-2005	0	20	70	120	1212	777	687	159	116	NA	NA	NA	3161
2003-2004	0	12	40	613	10598	4671	207	110	0	NA	NA	NA	16251
2002-2003	0	0	413	13627	3818	2357	823	203	61	NA	NA	NA	21302
2001-2002	0	0	3	1169	1559	2400	583	37	42	NA	NA	NA	5793
2000-2001	0	0	89	543	5332	5925	720	69	12	NA	NA	NA	12690
1999-2000	3	60				1243	426	87	48	NA	NA	NA	1867
Sum	3	92	625	16946	30239	26174	6982	1276	955	22	0	0	85314
Avg	0	9	69	1883	3360	2817	698	128	96	11	0	0	9071
SH %/yr	0.0	0.1	0.8	20.8	37.0	31.1	7.7	1.4	1.1	0.1	0.0	0.0	

d. Southern DPS of North American Green Sturgeon

For green sturgeon, the action area functions as migratory, holding, and rearing habitat for adults, subadults, and juveniles since their presence is considered year-round in the Delta. Juvenile green sturgeon have been collected at the CVP/SWP South Delta Fish Facilities throughout the year (Appendix A, Figure 7). Green sturgeon numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981–2015, green sturgeon may be present during any month of the year, but only a few juveniles have been observed since 2011. The average size of salvaged green sturgeon is 330 mm (range 136 mm–774 mm). The size range indicates that these are sub-adults rather than adult or larval/juvenile fish. These sub-adult fish likely utilize the Delta for rearing for a period of up to approximately 3 years. Observations of sport caught green sturgeon in the San Joaquin River indicate that sub-adult green sturgeon have a strong potential to be present within the action area during the Project work window (CDFW 2011). It is likely that their population density would be low within the action area. It is difficult to draw conclusions from the lack of observations in the monitoring data, since green sturgeon are benthic species and are not typically caught in surface-oriented gear like trawls and seines.

2. Condition of Critical Habitat within the Action Area

The action area is within designated critical habitat for CCV steelhead and sDPS green sturgeon (Table 7). The physical condition of critical habitat within the action area is degraded and limited primarily due to altered and diminished freshwater flows, loss of riparian habitat (rock rip-rap), introduced non-native invasive species, with a long history of agricultural and continued urbanization (*e.g.* boat docks, marinas, housing projects, *etc*).

Table 7. Critical Habitat Designation within Action Area (source: FR Notices)

Listed Species Name	Areas of Critical Habitat Designated within Action Area
Winter-run Chinook salmon	No
Spring-run Chinook salmon	No
CCV steelhead	Yes, for Dutch Slough, Sandmound Slough, and Rock Slough only from the confluence with Sandmound Slough east to Old River.
Green Sturgeon	Yes, for Dutch Slough and Sandmound Slough. No, for Rock Slough, all reaches are excluded upstream of the junction with Old River.

The PBFs of CCV steelhead habitat within the action area include freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The physical features of the PBFs included in the action area essential to the conservation of the CCV steelhead DPS include the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrients sources, natural cover and shelter, migration routes free from obstructions, no excessive predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater and estuarine rearing as well as migration by CCV steelhead juveniles and smolts and for adult freshwater migration.

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for CCV steelhead residing in the San Joaquin River basin. This segment of the steelhead DPS must pass through the southern portion of the San Joaquin Delta to reach their upstream spawning and freshwater rearing areas and to pass through the region again during the downstream migrations (both for adults runbacks and juvenile smolts). Therefore, it is of critical importance to the long-term viability of the San Joaquin River basin portion of the CCV steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat through the sloughs within the action area.

The PBFs of sDPS green sturgeon habitat within the action area includes: adequate food resources for all life stages utilizing the Delta; water flows sufficient to allow adults, subadults, and juveniles to orient to flows for migration and normal behavioral responses; water quality sufficient to allow normal physiological and behavioral responses; unobstructed migratory corridors for all life stages utilizing the Delta; a broad spectrum of water depths to satisfy the needs of the different life stages present in the estuary; and sediment with sufficiently low contaminant burdens to allow for normal physiological and behavioral responses to the environment. Unlike salmonids, juvenile green sturgeon may spend from 1-3 year rearing in this habitat. It is important to both adult and juvenile sDPS green sturgeon to maintain the value of the critical habitat within the action area to provide a migratory corridor and freshwater rearing area within the Delta.

The general condition and function of habitat within the action area has already been described in the *Status of the Species and Critical Habitat* section of this Opinion. The substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. Within the action area, the banks have been heavily rip-rapped with rock slope protection on artificial levee banks. These channels have been straightened and deepened to enhance water conveyance through the system (*i.e.*, Rock Slough and Sandmound Slough). The extensive riprapping and levee construction has precluded natural river channel migrations and the formation of riffle pool configurations in the Delta's channels. Natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been cleared for farming. A small fraction of the historical wetlands exists within the action area at the junction of Dutch Slough and Sandmound Slough and in the northern sand dune preserve. Little riparian vegetation remains in the south Delta, except for tules growing along the foot of the levee banks. Numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (*i.e.*, Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, *etc.*). These artificial channels have disturbed the natural flow of water through the south Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment (*e.g.*, RD 799).

Water flow through the south Delta is highly manipulated to serve human purposes. Rainfall and snowmelt is captured by reservoirs in the upper watersheds, from which its release is dictated primarily by downstream human needs. The SWP and CVP pumps draw water towards the southwest comer of the Delta which creates a net upstream flow (reverse flow) of water towards their intake points. Fish, and the forage base they depend upon for food, represented by free floating phytoplankton and zooplankton, as well as larval, juvenile, and adult forms, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the south Delta, numerous discharges from wastewater treatment plants, untreated agricultural returns, and stormwater discharges are emptied into the waters of the south Delta sloughs and channels. This contributes to the cumulative thermal effluent loads, as well as cumulative loads of potential contaminants (*i.e.*, selenium, boron, endocrine disruptors, pesticides, bio-stimulatory compounds, *etc.*).

2.4 Effects of the Action on Species and Designated Critical Habitat

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. Interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the proposed action.

The potential impacts of the proposed Project fall into two main categories: 1) construction of the Rock Slough Bridge that would result in increased turbidity, increased sound, resuspension of sediments, degradation of aquatic habitat, and permanent loss of habitat; and 2) increased stormwater releases that could result in increased pollutants and increased turbidity.

1. Construction Impacts

a. Turbidity and Resuspension of Sediments

Construction activities associated with the proposed Rock Slough Bridge will create conditions that result in a localized increase in turbidity through the resuspension of sediments in Rock Slough. The extent of turbidity plumes resulting from the Project will depend on the tide, currents, and wind conditions during these activities. Tidal exchange in Rock Slough varies from 1 to 4 feet. Velocities measured at the Rock Slough Fish Screen varied from 0 to 0.40 feet/second with a daily average of 0.14 feet/second (Reclamation 2012). The Project applicant will monitor turbidity following the Project's Turbidity Monitoring Plan. Turbidity will be measured twice a day during construction activities. The general objective for turbidity in Delta waters, except during periods of storm runoff, is not to exceed 50 NTUs (RWQCB 2011). Turbidity limits are set by the RWQCB and CDFW to not exceed an increase greater than 15 NTU. If downstream turbidity levels are more than 15 NTUs higher compared to levels upstream of the Project, activities will cease until background turbidity levels drop below 15 NTUs.

Within the immediate vicinity of the Rock Slough Bridge, fish that are subjected to high levels of turbidity and suspended sediment may suffer reduced feeding ability and be prone to gill injuries. Based on the timing of the Project, construction will occur from August 1 through October 15 over a 2-year period. NMFS expects turbidity and suspended sediment effects to be experienced mostly by adult CCV steelhead migrating upstream to the tributaries of the San Joaquin River and by green sturgeon that may be rearing or holding in the action area. Although there is the potential for juvenile CCV steelhead smolts to be migrating downstream at this time, their numbers are expected to be very low compared to the peak of emigration in spring and would tend to be associated with rain events or pulse flow operations on the tributaries. Fish monitoring (CDFW surveys) near the action area showed juvenile steelhead were not observed in the south Delta from August through October (Reclamation 2016). Since green sturgeon juveniles and adults are assumed present in the action area year-round, they would not benefit from proposed work windows. Green sturgeon can occupy waters containing variable levels of suspended sediment and turbidity, thus they are expected to avoid the Rock Slough area and not be physically harmed by the slight increase in the turbidity levels anticipated from the pile removal and pile driving.

Resuspension of sediments is similar to the effects of turbidity described above (Ingersoll 1995). Sediments may be resuspended during pile driving or during rip-rap replacement. Contaminants contained in the sediments may be released into the water column during pile driving. Contaminants of concern include copper, selenium, mercury, cadmium, polychlorinated biphenyls (PCBs), PAHs, pesticides, and herbicides, which are wide-spread in the Delta due to municipal discharges and commercial use of marinas. The construction activities present the potential for the resuspension of contaminants to the water column during pile driving. Uptake of contaminants in resuspended sediments by listed fish species can cause physical injury and behavioral changes (Eisler 1987, Johnson *et al.* 2002, Dwyer *et al.* 2005, Meador *et al.* 2006). However, most contaminants are tightly bound to the sediments and not easily released during short-term resuspension (Corps 2004). Chemical reactions that occur when sediments are disturbed can change the form of the contaminant and alter its availability to organisms. Turbidity and resuspension of sediments are expected to be dissipated by the significant tidal movement in the action area (twice/day). The temporary nature of the impact and physical features in Rock Slough (*e.g.*, tule stands, rock barrier, bridge abutments, dense mats of aquatic weeds, and 90 degree turns) are expected to confine these effects to the immediate vicinity of the construction site. Turbidity plumes are expected to be temporary, minor, and localized to the area within Rock Slough. With the Project's monitoring plan and utilization of measures to reduce or contain turbidity, NMFS expects that the increased levels of turbidity and resuspended sediment will not rise to levels that result impacts to listed fish species. Rock Slough is large enough that any listed fish that encounter turbidity or resuspended sediments can swim away from the area of disturbance. Studies have documented that many fish species, such as chum salmon, juvenile herring, and juvenile coho salmon, avoid areas that have increased turbidity (Corps 2004).

During construction, boat traffic around the Rock Slough Bridge will temporarily increase. Work boats and barges will be used to move materials to and from the construction site and act as a platform from which to drive the piles. Effects from the use of work boats and material barges will last for the duration of the in-water work window (*i.e.*, 2.5 months from August 1 through October 15). Acoustic effects from the use of work boats and material barges are anticipated to be minimal, and are not expected to rise to the level where fish species could be impacted (*i.e.*, above the background level of 150 dB). No interdependent effects are expected as a result of the Project since all construction activities are considered as part of Project.

Unanticipated spills into Rock Slough from toxic substances using during bridge construction (*i.e.*, gasoline, diesel, or hydraulic fluids) can lead to negative effects and mortality in juvenile and adult salmonids and green sturgeon. If these toxic materials seep into the water, exposure to lethal concentrations can kill aquatic organisms, and exposure to non-lethal concentrations can cause physiological stress and reduce the ability to survive and reproduce. However, NMFS expects that the contractor will adhere to the standard BMPs and a Spill Prevention and Control Plan during the construction and pile driving activities to prevent these kinds of effects on listed fish species. Therefore, NMFS does not expect the Project will result in water contamination effects that will injure or kill listed salmonids or green sturgeon.

b. Acoustic Impacts of Pile Driving

High levels of underwater acoustic noises have been shown to have negative impacts upon fish. The Project applicant proposes to limit the pile driving activity to daylight hours during approximately 25 days from August 1 to October 15. In general, underwater sound dissipates with distance from the source. In an ideal model, the intensity of the sound energy produced at the point source spreads itself out over a spherical surface so that by conservation of energy, the total energy spread over the spherical surface at any given distance from the point source is equal to the energy at the point source. The decrease in acoustic pressure as the sound pressure wave propagates underwater away from the source is called transmission loss (TL).

Under actual conditions, TL is complicated by the water surface and channel bottom reflecting sound energy back into the water column and the formation of constructive and destructive sound wave interference. Although there are limited data documenting the effects of extreme sound pressure specific to salmonids (Halvorsen *et al.* 2011, and 2012), a review of studies by Popper and Hastings (2009) on fish in general found that those fishes with anatomical specializations that make them better able to detect lower levels of sound pressure (*i.e.* hearing specialists) may be more susceptible to sound-induced hearing loss. For fish with anatomical hearing specializations, Popper and Hastings' (2009) review showed a pattern of hearing loss when exposed to increased background noise levels for 24 hours or more, whereas fishes without such specializations (*i.e.* hearing generalists) did not necessarily show hearing loss. For example, Smith *et al.* (2004, 2006) examined hearing loss after over 20 days of exposure to a broadband noise of 170 dB and found that there was a substantial hearing loss in goldfish (*Carassius auratus*), a fish with hearing specializations, making it more sensitive to sound pressure, but not in the Nile tilapia (*Oreochromis niloticus*), a fish without such specializations.

NMFS assumes that some level of negative impacts to salmonids can be inferred from the above results because of the similarity in anatomical hearing specializations of salmonids compared to the fishes represented in the studies reviewed by Popper and Hastings (2009). Exposures of these other fish species can serve as surrogates for salmonids, although sound exposure of 24 hours would not apply. The thresholds used by NMFS and other agencies for the onset of physical injury to fish > 2 grams are peak sound pressure level = 206 decibels (dB) and cumulative sound exposure level (SEL) = 187 dB (Fisheries Hydroacoustic Working Group 2008). Based on life history, all NMFS listed fish species would be > 2 grams by the time they reached the action area in the south Delta. For avoiding negative behavioral effects to fish, NMFS uses Root Mean Square pressure (RMS) = 150 dB. Since the sound levels for vibratory pile driving (*i.e.,* 172–185 dB) are expected to be below the physical injury level (SEL of 187 dB), negative impacts are likely to be behavioral (*i.e.* fish will move away from the sound) and dissipate to background levels (*i.e.,* RMS < 150 dB) within a short distance from the Rock Slough Bridge. The Project applicant proposes to install 24 temporary 14-inch diameter steel pin piles for templates using a vibratory hammer. Based on similar-sized piles (13-inch diameter), the measured sound levels are not expected to exceed 155 dB RMS and 155 dB SEL for a vibratory hammer (Illingworth and Rodkin 2007). All pile driving would occur during the day and it is estimated to take 5 days to install the 24 steel pin piles. Therefore, acoustic impacts from driving and removing the 24 temporary pin piles are not likely to rise to the level of adverse effects that cause harm to salmonids.

To assess acoustic impacts for the larger size piles (24 and 48 inch diameter) the Project applicant proposed two approaches; 1) start pile driving with a vibratory hammer and finish (proof) with an impact hammer, 2) use an impact hammer for the entire installation. These approaches allow for a best and worse-case scenario. The NMFS pile driving calculator was used to estimate the sound generated (Reclamation 2016, Appendix D). The NMFS calculator uses a practical spreading formula to account for TL and predict sound levels at various distances from the source.
Model results of acoustic impacts from impact hammers are shown below in Table 8 and 9.

Table 8. Modeled exposure distances for various sound pressure levels from pile driving without attenuation devices from NMFS calculator for fish > 2 grams (Appendix D in Reclamation 2016). n/a = not applicable for vibratory hammer

Number and Type of Pile (Size of Piles)	Estimated Strikes per day	Peak Sound Pressure Level (lethal, 206 dB)	Physical Injury (SEL 187 dB)	Behavioral Impacts (RMS 150 dB)
24 steel (14 inch)	n/a	n/a	n/a	30 feet
16 steel (24-inch)	120	20 feet	200 feet	13,061 feet
16 steel (24-inch)	1800	20 feet	1,220 feet	13,061 feet
8 CISS (48 inch)	220	30 feet	879 feet	32,808 feet
8 CISS (48 inch)	7,680	30 feet	7,067 feet	32,808 feet

Table 9. Estimated time for pile driving

Number and Type of Pile (Size of Piles)	Number/day (total duration)
24 steel (14 inch) vibratory only	5/day (5 days)
16 steel (24-inch) vibratory & impact	5/day (4 days)
8 CISS (48 inch) vibratory & impact	2/day (4 days)
Cofferdam sheet piles vibratory only	(3 days)
Removal of 24 (14 inch) vibratory only	5/day (5 days)
Total days	21 days (or 4-5 weeks)

Actual sound impacts may vary depending on fish species and real world conditions mentioned above. Sound attenuation devices (*i.e.*, cushion blocks, air bubble curtains, bubble rings, and use of pipe caissons), when used in slowly moving water like Rock Slough, have reduced noise from 5 to 15 dB (Illingworth and Rodkin 2007). The physical characteristics of the Rock Slough channel will also attenuate underwater sound.

Rock Slough, in the vicinity of the proposed bridge, is a relatively straight slough with rip-rap on both banks. The entire length of Rock Slough from its terminus near the Rock Slough Fish Screen to where the slough bends at the 90 degree angle is 2.9 miles (Figure 2). The width of Rock Slough near the proposed bridge is approximately 165 feet and widens to approximately 410 feet just prior to a 90 degree bend in the slough. The proposed bridge is located 250 feet from the CCWD intake and fish screen (Figure 23). To the east Rock Slough ends at the confluence with Old River. From the north, Sandmound Slough intersects Rock Slough approximately 0.9 mile east of the proposed bridge site. There is a rock dike barrier across Sandmound Slough approximately 0.1 mile above its confluence with Rock Slough. An existing two-lane bridge, the Delta Road Bridge, has eight pilings in Rock Slough and crosses Rock Slough at its narrowest width (161 feet) just east of the confluence with Sandmound Slough. Several dense stands of tules are found in the center of Rock Slough beginning at the confluence of Sandmound Slough and continuing east (Figure 22). The largest of these stands measures approximately two acres. In addition, there are pilings and boat docks that extend out into Rock Slough at Lindquist Marina. All together, these physical features will block or reflect the sound impacts from the bridge construction.

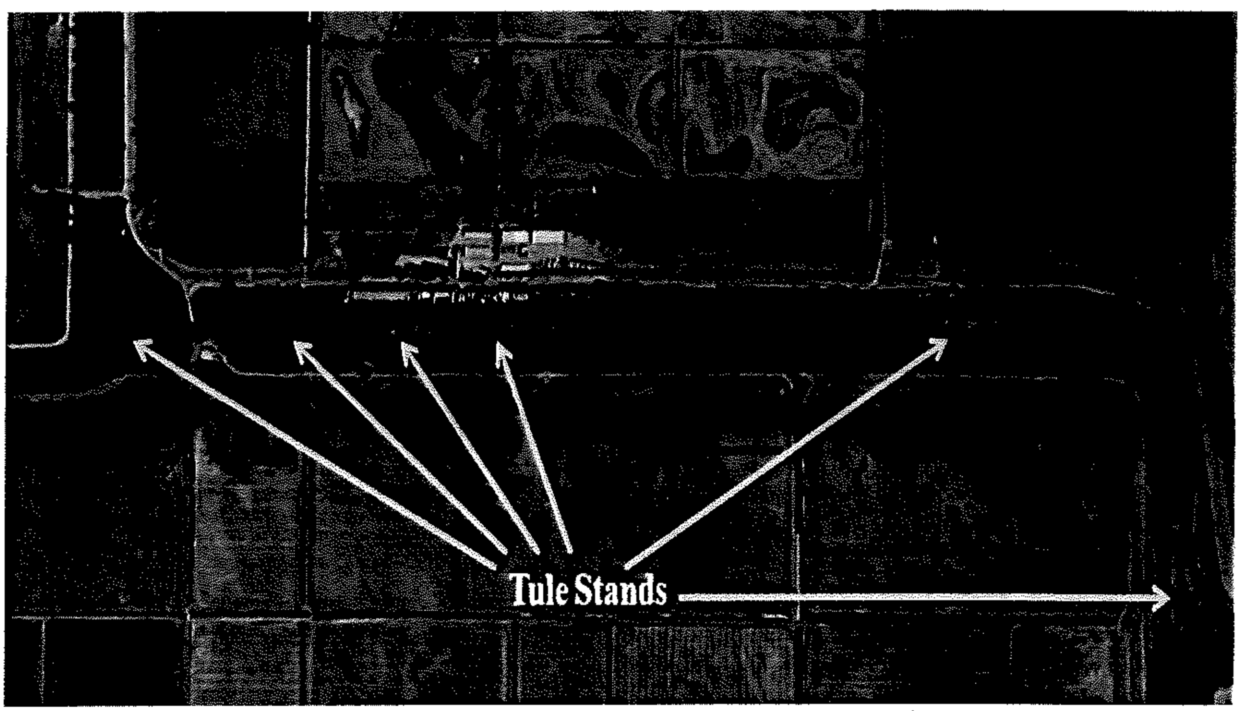

Figure 22. Physical features in Rock Slough showing Delta Road Bridge, Lindquist Marina, rock barrier, and tule stands.

The acoustic impacts would be different on adults (salmon, steelhead or sturgeon) versus juveniles. Adults, due to their larger size, can tolerate higher pressure levels than juveniles and immediate mortality rates are expected to be less. Rassmusen (1967) found that immediate mortality of juvenile salmonids may occur at sound pressure levels > 208 dB, however, < 180 dB no mortality would be expected. A gradual increase in the magnitude of physical injury is likely from 150 dB to 208 dB. However, with the sound reduction measures proposed during pile driving, sound levels are not expected to exceed 206 dB. Sound generated from driving the permanent piles will be attenuated by either maintaining a dewatered void within the oversize steel casings or allowing water to fill the space within the oversized steel casings and installing and operating a bubble curtain or bubble trees between the casings and the permanent piles throughout the pile driving operation.

Based on the modeling results from (Table 8 in Reclamation 2016), the distance that mortality (peak > 206 dB) to juvenile salmonids could occur is from 20 to 30 feet from the pile driving. The distance that physical injury (cumulative SEL > 187 dB) ranges from 200 to 1,220 feet for the 24-inch diameter steel piles (Figure 23), to 879 to 7,067 feet for the 48-inch diameter CISS piles (Figure 24), depending on the use of an impact hammer (*i.e.*, range is from best case to worse-case scenario). This is enough of an impact to kill or injure any juvenile salmonids that happen to be migrating through Rock Slough at the time of construction. In the worse-case, the underwater sound impacts for physical injury would extend for 1.3 miles in Rock Slough, if an impact hammer is used the entire time (Figure 24).

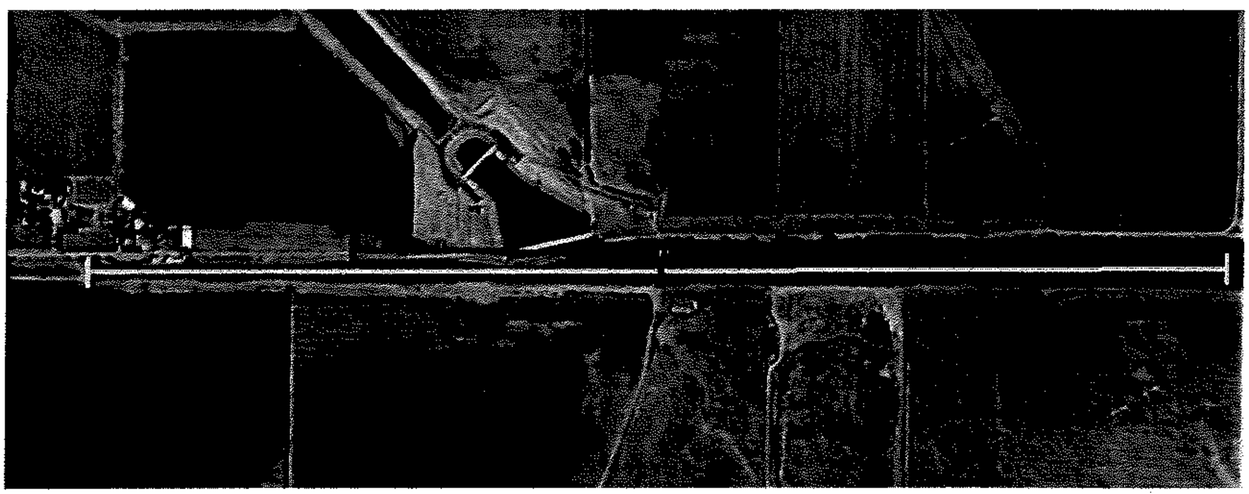

Figure 23. Rock Slough fish screen and proposed bridge (in red). Distances (feet) of potential physical injury caused by sound generated by using only an impact hammer to drive 24-inch steel piles for a total of 1,800 strikes per day for a period of 4 days. Distances are 1,220 feet (green) for fishes > 2 grams (187 dB), and 2,254 feet (yellow) for fishes < 2 grams (183 dB).

Figure 24. Rock Slough showing sound impacts for worse-case scenario. Distances (feet) of potential physical injury caused by sound generated by using only an impact hammer drive 48-inch diameter CISS piles for a total of 7,680 strikes per day for 4 days. Distances are 7,067 feet (green) for fishes > 2 grams (187 dB), and also 7,067 feet (yellow) for fishes < 2 grams (183 dB).

The sound impacts from pile driving would not extend into Sandmound Slough because it is blocked by a rock barrier at the confluence with Rock Slough. Sound impacts under the worse-case scenario are not expected to extend much past the Delta Road Bridge (7,067 feet) in Rock Slough due to dense stands of tules, aquatic weeds, and the bridge pilings that will buffer or deflect sound pressure waves (Figure 22).

The potential for negative behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected by underwater sound produced during pile driving. The loss of hearing sensitivity may negatively affect a salmonid's ability to orient itself (*i.e.*, due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Fish also may exhibit noise-induced avoidance behavior that causes them to move into less-suitable habitat. In the action area, this may result in adult or juvenile salmonids fleeing the pile driving-associated noises and moving into areas unsuitable for salmonids (*e.g.*, high temperature, low dissolved oxygen, or areas choked with aquatic weeds). Likewise, chronic noise exposure can reduce their ability to detect predators either by reducing the sensitivity of the auditory response in the exposed salmonid or masking the noise of an approaching predator. Disruption of the exposed salmonid's ability to maintain position or swim with the school will enhance its potential as a target for predators. Unusual behavior or swimming characteristics single out an individual fish and allow a predator to focus its attack upon that fish more effectively. Green sturgeon in the action area are expected to move away from Rock Slough into Old River.

Underwater sound exposures have also been shown to alter the behavior of fishes (Hastings and Popper 2005). The observed behavioral changes include startle responses and increases in stress hormones. The startle response in fishes is a quick burst of swimming that may be involved in predator avoidance. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. Exposure to pile driving sound pressure levels may also result in "agitation" of fishes indicated by a change in swimming behavior detected by Shin (1995), or "alarm" detected by Fewtrell (2003). Other potential effects include reduced predator awareness and reduced feeding. Adult and juvenile salmonids are likely to exhibit avoidance behavior within Rock Slough, which may increase straying rates, alter feeding patterns, and reduce the ability to avoid predators.

The proposed bridge location at the end of Rock Slough will minimize sound disturbance in Rock Slough, however, any fish present at the start of pile driving could be forced onto the Rock Slough Fish Screen or trapped at the dead end of Rock Slough where conditions are lethal (*i.e.*, high temperature, low dissolved oxygen, and large amounts of aquatic weeds). The maximum area (7,067 feet) within Rock Slough that will be temporarily impacted is approximately half of its total distance (Figure 24). The majority of Rock Slough is available for fish to move away from the zone of increasing noise impacts. For the purposes of this analysis, the zone of potential impact is defined as the area where there may be injury or mortality to listed salmonids and green sturgeon (*i.e.*, sound impacts from 187 dB to 206 dB SEL), which is 27-123 acres. Within this zone, listed fish species could experience a range of barotraumas or auditory damage described above (Casper *et al.* 2012b). These injuries could result in immediate or delayed death. Fish within the range of 150 dB RMS (behavioral effects) may demonstrate temporary abnormal behavior indicative of stress or exhibit a startle response. As described previously, a fish that exhibits a startle response is not injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment, and startle responses are likely to discontinue after the first few pile strikes.

Due to the timing of the in-water work, (25 days from August 1 through October 15), the majority of the noise impacts created by pile driving activity are expected to be experienced by only a very small number of adult CCV steelhead migrating upstream that might stray from Old river into Rock Slough. Fish monitoring has observed an occasional adult steelhead at the Rock Slough Fish Screen during this time period. Juvenile salmonids are not expected to be present during this time period. In addition, pile driving during daytime only will allow fish to move past the area of behavioral impacts and the nature of pile driving (*i.e.*, breaks and delays while setting up new sections of pipe) allows fish time to flee the area.

The majority of adult salmon and steelhead migration occurs after the pile driving is completed in October, allowing adults to avoid exposure to any noise-related construction operations. Adult spring-run and winter-run Chinook salmon are not expected to be present in the action area during construction or pile driving activity. Therefore adult salmonids are not expected to be physically harmed or killed by the pile driving. CCV steelhead that may be present in the area in October are expected to exhibit a startle response or behavioral avoidance.

The Project's minimization measures (*i.e.*, daytime only pile driving) will provide periods of time at night and between set-ups when listed fish species can pass through the action area without being injured or forced to move away. The largest area of Rock Slough is only affected if an impact hammer is used to drive the 48-inch diameter CISS; however pile installation will occur only during the daytime for four days, thus limiting the exposure of salmonids to increased sound levels. The nature of pile driving itself allows times during the day when no piling driving is taking place (*e.g.*, moving pile locations, re-aligning, and welding new sections). Therefore, there are safe periods of time when fish can avoid physical injury. Thus, the negative effects of pile driving sound will be reduced, but not eliminated. There is still the potential for underwater sound to physically injury, kill, or alter fish behavior, depending on the distance from the pile driving.

The impact of underwater acoustical noise upon green sturgeon is uncertain. NMFS has not found any specific reference literature investigating the hearing capabilities of green sturgeon. An important physiological aspect of sturgeon, with regard to their hearing, is that they lack a gas bladder. Casper *et al.* (2012a) has shown that fish species, such as sharks and sturgeons, that lack gas bladders tend to be less sensitive to noise in the marine environment. Since sturgeon lack a gas bladder, it is likely that green sturgeon would be less sensitive to anthropogenic noise effects. Sturgeon exposed to an accumulated SEL exceeding 187 dB can be physically injured, and this potentially could lead to delayed mortality (Clark and Hoover 2009). Since green sturgeon in Rock Slough would be repeatedly exposed to the underwater sound within the action area, it is likely that they would be either physically injured, or move out of the area to avoid injury. Noise may displace or impede green sturgeon that are rearing or holding in the action area, causing disruptions in feeding and sheltering behavior of individuals. Prolonged exposure to high sound levels may also result in temporary impacts to hearing ability.

Green sturgeon that are rearing or holding in Rock Slough could be repeatedly exposed to sound effects over the 25 days of pile driving. However, the habitat in Rock Slough is not likely suitable for green sturgeon. The fish monitoring to date has never observed a green sturgeon at the Rock Slough fish screen or in nearby CDFW monitoring locations (Reclamation 2016). The minimization measures being implemented (*e.g.*, bubble curtain, cushion blocks) will reduce, but not eliminate, the negative effects of underwater noise. Based on model results, within 20-30 feet of the Rock Slough Bridge green sturgeon will likely be killed if they stay in the area during pile driving. From 30 to 7,067 feet (1.3 miles), green sturgeon will be physically injured, however, green sturgeon are likely to exhibit avoidance behavior similar to salmon, such as altering their feeding pattern and moving into less suitable habitat in Old River. These less suitable areas may cause a higher risk of entrainment due to CVP or SWP pumping facilities, predation, or reduced food availability.

Given that adult green sturgeon lack a gas bladder and are larger than salmon, they could, presumably, tolerate higher levels of sound pressure and be less affected by pile driving activities. Similarly, juvenile green sturgeon are typically around 600 mm in length by the time they inhabit the estuary, close in size to some adult salmonids, therefore it is anticipated that they will also be more resilient and capable of recovering quickly from temporary disturbances associated with pile driving. However, they are vulnerable to injury or death from pile driving (especially within 30 feet of the pile driving), as demonstrated by sound impacts that resulted in the death of a sturgeon documented during the construction of the Benicia-Martinez Bridge installation (NMFS 2003).

In summary, the model results and literature information suggest a fish larger than 2 grams may be injured or killed by sound impacts exceeding 187dB SEL. However, several factors will reduce the number of green sturgeon or salmonids potentially injured or killed by pile driving during construction of the Rock Slough Bridge. First, pile driving will not be continuous over the entire work day because of the set-up time required between pile installations. In order to reach a cumulative SEL of 206 dB capable of killing a fish, an individual fish would have to remain within 30 feet of the pile driving for more than 6 hours. Given the tidal action in the action area and migration behavior of salmonids (typically move through the area in a matter of hours), this would be unlikely. For green sturgeon, repeated disturbance by sound impacts are likely to cause them to move outside of Rock Slough into deeper water. Secondly, the area of potential injury or mortality is constrained by the physical features within Rock Slough to a very small area (27 acres) compared to the action area (1,247 acres) and the surface water within the Delta (61,000 acres) (*http://www.water.ca.gov/swp/delta.cfm*). Thirdly, the sound made by construction crews prior to initiation of pile driving is likely to be perceived by fish as a stimulus indicating potential danger, and listed fish are not expected to remain in the area directly adjacent to a pile (*i.e.,* within 30 feet).

c. Temporary and Permanent Loss of Aquatic Habitat

There will be a temporary loss of 25.4 square feet (0.0006 acre) of benthic habitat from placement of the 24 steel pin piles for the pile driving template and a temporary loss of 37.7 square feet (0.0009 acre) as a result of the installation of the 12 in-water 24-inch steel trestle piles for the work trestles. There would be a temporary loss of benthic organisms that provide food for listed species such as green sturgeon. Due to the short time period for in-water pile driving (4 weeks), benthic organisms are expected to quickly recolonize the impacted area from the surrounding undisturbed portions of Rock Slough. Benthic macroinvertebrates were found to recolonize disturbed sites within 4 weeks and diversity within 2 weeks following gravel replacement in the Mokelumne River in California (Merz and Chan 2005).

Construction of the Rock Slough Bridge will result in the permanent loss of 100.5 square feet (0.002 acre) of benthic habitat from installation of the eight 48-inch CISS piles that will be placed permanently in the waters of Rock Slough. The bottom substrate provides habitat for benthic organisms such as amphipods, mollusks, and polychaetes that provide food for listed species. Approximately 55.9 cubic yards of water column habitat will be permanently lost in Rock Slough as a result of the eight permanent CISS pilings that support the bridge. Water column habitat contains zooplankton and phytoplankton, among other organisms, which provide prey for juvenile salmonids and green sturgeon.

In addition, the Rock Slough Bridge will create a permanently shaded area under the bridge. Shading such as under docks and bridges can increase predation to juvenile fish, cause loss of productivity, and decrease aquatic vegetation (USFWS 2004). The shading from the Rock Slough Bridge will result in a 9,565 square foot (0.22 acre) shadow zone over Rock Slough.

The temporary loss of habitat from the piles for the driving template (0.0006 acre) and the trestle piles for the work platforms (0.0009 acre) is unlikely to affect listed salmonids since adults and juveniles are not expected to be in the area during the work window. Benthic areas beneath the temporary piles will be recolonized by organisms from the surrounding undisturbed areas (Oliver *et al.* 1977, Currie and Parry 1996, Watling *et al.* 2001). In the unlikely event that some individuals are present, construction activities such as noise and turbidity are likely to cause juvenile or adults to avoid the area. For green sturgeon, the temporary loss of habitat is not expected to impact subadults or adults, as most green sturgeon will move away from the area of disturbance.

The community of benthic species, which provide prey for CCV steelhead and green sturgeon, will be temporarily disturbed during construction, but is expected to re-establish from the surrounding intact areas (Merz and Chan 2005). Therefore, the impacts of habitat loss to the benthic prey community during construction are not expected to rise to the level where they would negative impact listed fish.

The impacts from the permanent loss of 100.5 square feet (0.002 acre) of benthic habitat, 55.9 cubic yards of water column habitat from the eight 48-inch CISS bridge piles, and the shading of 9,565 square foot (0.22 acre) of habitat have been fully mitigated through purchase of three conservation credits from the Kimball Island Mitigation Bank.

2. Stormwater Discharge

The development of residential and commercial areas within the Project are typically associated with an increase in impervious surfaces that leads to increases in the rate and volume of stormwater runoff (Rantz 1971 *op. cit.* Balance Hydrologics 2015). Approximately 42% of the 1,246.4-acres planned for development would be covered by imperious surfaces such as homes, schools, shopping centers, and roads. Non-point pollution from driveways, roads, and parking lots could contribute petroleum products and heavy metals to storm runoff and degrade water quality in Dutch and Sandmound sloughs (*i.e.*, where pump stations 2 and 4 are located, see Figure 1). Pesticides and fertilizers applied to residential and commercial landscaping could also be mobilized by rainfall and be transported to the Delta sloughs, potentially affecting aquatic and terrestrial wildlife species in the river or the adjacent riparian zone. The discharge of stormwater could result in direct effects to listed species, such as mortality, or indirect effects such as a loss of prey or foraging habitat through release of contaminants and increased turbidity.

Control of stormwater runoff is regulated by the Central Valley Regional Water Quality Control Board (RWQCB 1998, 2011). Counties and cities that implement a comprehensive control program for urban developments that meets Regional Board standards can apply to the RWQCB for a joint city-county National Pollutant Discharge Elimination System (NPDES) permit. Upon acceptance, the authority to regulate storm runoff discharges from municipal storm drain systems is transferred to the permit holders, allowing them to more effectively integrate the stormwater control program with other nonpoint source control programs. Although, the City of Oakley is covered under the Region 5 RWQCB permit, it is subject to special conditions (issued September 23, 2010) that essentially require implementation of measures in the Region 2 Municipal

Regional Permit. The NPDES permit program is monitored by the Contra Costa County Clean Water Program.

All developers in the Cypress Preserve Project will be required to submit a Stormwater Management Plan, which will describe the strategy for maintaining the water quality of stormwater runoff and will include specific measures that will be implemented. The Stormwater Management Plans contain best management practices that will be required of the developers. The Project contains designated open space, landscaped areas, and cul-de-sac street designs that will provide separation between impervious areas and provide pervious areas, where, to a limited extent, infiltration and filtration can occur. Part of the design includes lakes that will play a significant role in the enhancement of water quality. Each lake would be lined to eliminate contact with the shallow ground water that is found in the area. The lakes include aeration, circulation, and filtration systems to provide control of nutrient and algal growth. No water will be withdrawn from the Delta for recharging the lakes, thus entrainment concerns are eliminated. Under the existing land use approximately 3,800 acre-feet of Delta water is withdrawn for irrigation purposes through unscreened diversions. The change in land use would eliminate the need to divert water from the Delta through these unscreened diversions.

Using the Project's lakes to provide stormwater detention is an effective strategy for minimizing and mitigating potential impacts to adjacent waterways from increases in stormwater runoff. The lakes' pump stations would be programmed so that the required stormwater treatment volume is detained in the lake system for a minimum of 48 hours to enhance sediment removal, biological uptake, photodegradation, and other pollutant removal mechanisms (Balance Hydrologics 2015). The modeling results presented in Appendix C (Reclamation 2016) demonstrate that there would be no overall increase in the discharge rate arriving at the RD799 pump stations from the Project. There would be no adverse erosion or sedimentation in the slough channels if the peak pumping rate is kept at or below existing rates.

Currently, the agricultural runoff from ranching operations is not treated prior to discharge in Dutch Slough and Sandmound Slough. The proposed Project would treat stormwater runoff before it enters the Delta through a system of retention lakes, thus providing an improvement to water quality over the current condition. Therefore, the impact on listed fish species would be considered a beneficial effect. The action area will change from its current agricultural use (mainly irrigated pasture land for cattle grazing) to a master-planned community that provides mixed-use commercial and residential development that includes recreation, open space, and wetland preservation. The lakes proposed for the Project would serve as a central treatment control element, and all runoff from the Project would be treated. The Project will comply with stormwater regulations and standards associated with the NPDES permit as administered by the City of Oakley, Contra Costa County (through the Contra Costa County Clean Water Program) and the CVRWQCB.

In summary, the effects of increased stormwater runoff are not likely to impact listed fish species. Once the retention lakes are built water quality is expected to improve compared to the existing condition. No water will be diverted from the Delta for the retention lakes and the design of the Project will reduce the rate of discharge.

a. Effects to Critical Habitat

The first principle of salmon conservation is that functioning, diverse, and interconnected habitats are necessary for a species to be viable (NMFS 2014). Unfortunately, within the action area the migratory corridor function of critical habitat is constrained by rock barriers, dense mats of aquatic weeds, and dead-end sloughs. Some habitat may function as rearing habitat for juvenile fish, but that is also impacted by the proliferation of marinas and boat docks in Dutch Slough, Sandmound Slough, and Rock Slough. A small portion of the migratory corridor function will be altered by construction effects (*i.e.*, placement of bridge piles, pile driving, turbidity, resuspension of contaminants, and replacement of rip-rap). However, these impacts are short-term and conditions are expected to return to ambient levels within a day or two of the bridge completion. All permanent effects (such as the loss of habitat from bridge piles) will occur in non-designated critical habitat, since Rock Slough is not included in the critical habitat designations. Impacts to rearing and foraging habitat associated with the proposed action are minimal and temporary. Impacts from stormwater discharge are expected to be better than existing conditions due to treatment before it enters the Delta. A very minimal amount of non-critical habitat will be permanently displace by the Rock Slough bridge pilings and shading (*i.e.*, 100.5 square feet or 0.002 acre of benthic habitat from pile driving, 55.9 cubic yards of water column habitat, and the degradation of 9,565 square feet or 0.22 acre of habitat by shading from the bridge). This permanent loss of habitat has already been fully mitigated through the purchase of three conservation credits from the Kimball Island Mitigation Bank in 2006. The three credits are equivalent to three acres of riverine aquatic bed habitat. The Kimball Island Mitigation Bank was successful in fulfilling its goals of creating self-sustaining vegetation communities that closely resemble the aquatic, wetland, and riparian habitats found in the Sacramento-San Joaquin Delta (Wildlands, Inc. 2006). Therefore, these effects are not significant enough to alter the existing habitat to the point where its function is impeded.

The exposure of previously sequestered contaminants in the sediments under the bridge could have a negative effect on the freshwater migration corridor and estuarine PBFs of CCV steelhead and green sturgeon critical habitat. Re-suspending contaminated sediments would have a negative effect on the water quality PBF of green sturgeon critical habitat in the immediate area of Sandmound Slough and possibly Old River. However, these effects are expected to be temporary and localized to the immediate area in Rock Slough due to the rock barrier and dense tule stands (Figure 22). As the natural chemical processes, described above, reduce active chemical compounds to non-reactive states, the habitats should return to their current degraded condition.

Under the worse-case scenario, the maximum area impacted by hydroacoustic effects is 123 acres at 150 dB level (return to ambient noise level), and the maximum area that physical injury could occur is 27 acres at the 187 dB SEL level. The maximum distance that fish could be impacted by sound > 150 dB extends for 7,067 feet in Rock Slough, past the Delta Road Bridge to the Lindquist Landing Marina (Figure 24). The area of critical habitat temporarily impacted by pile driving would be from the junction of Sandmound Slough past the Delta Bridge to the Holland Marina, or approximately 7 acres, and affects only critical habitat for CCV steelhead. Sound pressure waves are temporary effects that will not alter the physical properties of the habitat. However, the sound impacts could block fish migration, delay run timing, and alter the quality of the habitat by limiting its function during the in-water time period (25 days from August 1–October 15). For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. CCV steelhead can avoid this area during the in-water work window, therefore, the effects to critical habitat are not likely to be experienced by adults returning to the San Joaquin River tributaries.

The critical habitat and wetlands in Sandmound and Dutch Slough are not expected to be impacted by hydroacoustic effects due to the rock barrier that physically separates Sandmound Slough from Rock Slough. Therefore, the migration corridor and rearing function of critical habitat in those areas is not expected to be altered.

b. Operations of the CVP and CCWD Rock Slough Intake

No change in water project operations at the CVP or at CCWD's four water supply intakes is expected due to the proposed Project. The water supply for the residential development (estimated at 1,200 acre-feet per year) will be provided by annexing the CVP water service area. CCWD has an existing supply water contract with Reclamation. Currently, CCWD is not using the full contract amount. The diversion rate through the Rock Slough Intake may increase slightly in the future due to full build out of the residential development. However, the amount of water pumped from the Delta is balanced between Contra Costa's three other diversions (*i.e.*, Old River, Victoria Slough, and Mallard Slough) depending on salinity conditions. The actual pumping rate in Rock Slough, which has a capacity of 350 cfs, is not expected to change significantly from current levels. Currently, Rock Slough diverts approximately 250 cfs during the peak of summer demands.

CCWD diverts approximately 127,000 acre-feet per year total, of which approximately 110,000 acre-feet is CVP contract supply (NMFS 2009). The Cypress Preserve development would increase CCWD's total diversions to 128,200 acre-feet per year. The Rock Slough diversion accounts for approximately 10% of the annual diversions. However, due to a number of pumping restrictions (*e.g.*, USFWS and CDFW requirements, construction outages, weed problems), the actual amount of water diverted at Rock Slough has decreased over the last 5 years.

For the CVP operations, the impact of actual diversions from the Delta and upstream operations (*i.e.*, releases from reservoirs) have been previously consulted on in NMFS (2009). CCWD demands (*i.e.*, 2030 level of development) were projected to be 188,000 acre-feet per year (Reclamation 2008). Therefore, the anticipated increase in water use with the addition of the Cypress Preserve water service area (128,200 acre-feet) is not expected to exceed the 2030 level of development. The increase in future CCWD demands and the contribution to net negative flows on Old and Middle River flows have been previously analyzed in NMFS (2009).

The increase in water demand from the Project's assumed 1,200 acre-feet is equivalent to a minimal increase of approximately 1.5 cfs year-round from the Delta, which would most likely be diverted from CCWD's Middle River Intake instead of the Rock Slough Intake (Seedall 2016). This minimal change in diversion rate is not expected to impact fish in Rock Slough since all the CCWD intakes are fully screened. Planned improvements to the design of the cleaning system and annual weed control are anticipated to keep the Rock Slough fish screen operational.

Due to the close proximity of the proposed bridge across Rock Slough, Reclamation will relocate the log boom in front of the Rock Slough Fish Screen to the east side of the proposed Rock Slough Bridge. A proposed (*i.e.*, requirement in previous ESA consultations) block net will be hung from the log boom and block adult fish from swimming under the Rock Slough Bridge to the area in front of the fish screen. By moving the log boom, all access to the area in front of the fish screen and under the bridge are cut off to adult salmon, steelhead, and green sturgeon (larval fish can still access this area) and recreational boaters. This will reduce the area available to fishermen by 1.15 acres (306 feet x 164 feet). The loss of accessible area is not likely to impact recreational fishing since very few boaters utilize the area due to the proliferation of aquatic weeds and the close proximity to the terminal end of Rock Slough.

c. Increased Traffic and Non-Point Pollution

Increased automobile traffic over Rock Slough and into the residential developments will result after the bridge is built. The increased traffic will result in noise, non-point source pollution, vibrations, and increased likelihood of contaminants (*i.e.*, asbestos from brakes, gasoline spills, diesel, or hydraulic fluids) entering the water. In aquatic systems, automobile traffic, construction, and manufacturing activities can also generate significant underwater noise (Schwartz 1985). The importance of anthropogenic noise has only recently begun to be acknowledged and studied for fishes and invertebrates (Popper 2003).

In urbanizing areas, one of the most important sources of non-point source pollution is copper from automobiles. Vehicle exhaust contains copper, and the action of braking releases trace amounts of copper and other heavy metals from brake pads. Copper accumulates on highways, roads, parking lots, and similar surfaces until storm events mobilize the metal in runoff. Since conventional detention and treatment systems for runoff are designed to reduce the impacts of sedimentation and altered flow, they typically do not remove dissolved-phase copper from surface waters (McCarthy *et al.* 2008). Adult salmon returning to streams in coastal urban areas experienced pre-spawn mortality in minutes due to storm water runoff from streets and highways (Scholtz *et al.* 2010). Even low-level exposures to these contaminants can negatively affect juvenile salmon physiology and behavior (Sandahl *et al.* 2005, 2007), and they also pose potentially important but poorly understood threats to stream food webs that support juvenile salmon growth and survival (Spromberg and Scholz 2011).

Landscape scale urbanization and the cumulative impact from new highways have been shown to cause changes in the local fish assemblage, typically in favor of more non-native species (Weaver 1994 and Wheeler *et al.* 2005). The purpose of the Rock Slough Bridge is to relieve traffic congestion on East Cypress Road and provide a second point of access to the development area and Bethel Island for emergency vehicles (Reclamation 2016). Traffic is expected to be light until completion of the Project (projected to be by 2030). However, no data on traffic were provided. Currently, due to the rapid growth in the surrounding area, traffic is severely congested between Oakley and Brentwood. It is unknown when the Byron Highway extension will be built by the Contra Costa County Transportation Authority. Therefore, the impact of future increased traffic is likely to add to the cumulative effects of other developments in the action area.

The design of the Rock Slough Bridge will drain water away from the bridge to either land side of the bridge into ditches and not directly into the waters of Rock Slough.

The proposed bridge over Rock Slough is likely to increase predation due to shading 9,565 square feet or 0.22 acres of habitat and the addition of structures (*i.e.*, 100.5 square feet pilings) in the middle of the slough. The area under the Rock Slough Bridge provides cover from which predators can ambush prey as they are drawn towards the CCWD intake. Recent studies on predation (Sabal *et. al.* 2016) have shown a synergistic effect of habitat modification and nonnative predators in the Delta. This effect can exacerbate the mortality of young juvenile salmonids as they migrate though areas where predators are known to be present. At the Rock Slough Intake, non-native predatory fishes such as bluegill *(Lepomis macrochirus)*, largemouth bass *(Micropterus salmoides)*, striped bass *(Morone saxatilis)*, redear sunfish (*Lepomis microlophus)*, and white catfish (*Ictalurus catus*) comprised 56% of the total number of fishes collected during 13 years of study from 1999–2011 (Reclamation 2016). The impacts to habitat in Rock Slough were previously mitigated for with the purchase of three conservation credits from the Kimball Island Mitigation Bank. However, mitigation does not stop the impact from continuing to happen and adds to the cumulative effects of similar projects across the Delta. The effects of construction of the Rock Slough Bridge and the permanent loss of a small amount of benthic habitat are insignificant given the degraded habitat condition and status of ESA-listed species in the action area.

In summary, the indirect and interrelated effects from construction of the Rock Slough Bridge and storm water releases are not likely to negatively impact listed fish species. In the future, the increased automobile traffic (pollution from spills and trash) and increased predation from shading may add to the cumulative impact on steelhead and green sturgeon. However, these impacts are confined to a relatively small area (0.22 acres) and most likely only impact a small number of listed fish. In the 13 years (1999–2011) of juvenile fish monitoring at the Rock Slough Intake only 18 fall-run, 15 steelhead, 11 spring-run, and 3 unidentified Chinook salmon were observed (Reclamation 2016). This means that 3-4 salmonids per year are likely to be impacted by the Project in the future.

2. Beneficial Effects

The Project will provide a benefit to the Delta by diverting less water than is currently used for agriculture. Currently, 3,800 acre-feet of water per year are diverted for irrigation purposes. In the future, after full build out of the residential development, water diversion for the Project is expected to be 1,200 acre-feet per year (Seedall 2016). This leaves approximately 2,600 acre-feet per year of freshwater in the Delta for other beneficial uses.

Another beneficial effect is that stormwater discharge from the Project will be treated by retention in lakes before being pumped out to the Delta. This will improve water quality conditions compared to the current condition of untreated agricultural return water. The treatment of urban runoff from stormwater is identified as a priority one action in the Central Valley Recovery Plan (NMFS 2014).

In addition, creation of 133.9 acres of permanent wetlands or dunes; and 455.8 acres of open space, easements, lakes, and preserves will provide habitat for other wildlife species where only seasonal wetlands and ranch land exist today. Total undeveloped habitat is 47% of the Project, leaving open areas for water to percolate into the groundwater instead of running off into ditches. The creation of additional wetlands in the North Preserve and South Preserve will protect both preserves in perpetuity with establishment of an endowment to fund long-term management costs, and improve management of the preserves and other avoided wetlands within the development by managing the site for water quality and habitat values rather than ranching values.

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. Future non-Federal actions such as farming, urban growth, and climate change are listed below.

A. Agricultural Practices

Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may have a negative effect on salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003). The change in land use for this Project from cattle ranching to urban development is expected to reduce the amount of contaminants entering the Delta from stormwater discharge.

B. Increased Urbanization

The Delta, San Joaquin, and Sacramento regions, which include portions of Contra Costa, Solano, San Joaquin, and Sacramento counties, are some of the fastest growing regions in California. By 2020, these counties are expected to increase in population by more than 440,000 (http://www.dof.ca.gov/research/demographic/reports/projections/p-1/documents/pdf), and the whole of California is expected to increase in population by nearly 3 million people. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth has already placed 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 well 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 is also 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 stir up benthic sediments, thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This, in turn, would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the Delta.

C. 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 2001). 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 1998). Using objectively analyzed data, Huang and Liu (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 m to 1.0 m along the Pacific coast 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.*, estuarine, riverine, mud flats) affecting salmonid 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.

Droughts along the West Coast and in the interior Central Valley of California are already occurring and likely to increase with climate change. This means decreased groundwater storage and 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. Warmer stream temperatures will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Peterson and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2°C and 7°C (3.6°F and 12.6°F) by the year 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005, and Reclamation 2008), with a drier hydrology predominated by precipitation rather than snowfall. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. Summer temperatures and flow levels will likely 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 likely truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool from melting snow pack filling behind reservoirs in the spring and early summer, water temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids that must spawn below dams over the summer and fall periods.

From 2012–2015, California experienced one of the worst droughts in the last 83 years. Salmon, steelhead, and green sturgeon populations have experienced lower egg and juvenile survival due to poor freshwater conditions (*e.g.*, low flows, higher temperatures) caused by the drought. Adult abundance of listed salmonids and green sturgeon is expected to decline significantly after 2015, given the poor conditions since 2012. Within the context of the near-term effects of the last 4 years of drought, the 21 days that pile driving will actually take place are not likely to result in a decline to the overall health or distribution of the listed populations of anadromous fish within the action area. However, the decline due to drought and the impact of climate change will certainly be experienced during the much longer residential development phase of the Project (scheduled to be over the next 14 years).

2.6 Integration and Synthesis

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

This section integrates the current conditions described in the environmental baseline with the effects of the proposed action and the cumulative effects of future actions such as the Byron Highway extension, housing developments on Bethel Island (to the north), and Veale Tract (to the south) . The purpose of this synthesis is to develop an understanding of the likely short-term and long-term responses of listed species and critical habitats to the Project.

The potential effects of the Project can be grouped into two categories: (1) those that are a direct result of the bridge construction and pile driving activities, and (2) those that occur later in time such as stormwater discharge from urban development. Effects associated with these two categories are not necessarily expected to be uniformly distributed across the entire action area. Instead, effects associated with the bridge construction are expected to be contained within Rock Slough, while the effects associated with stormwater discharge extend outward into the Delta at Dutch Slough and Sandmound Slough.

The environmental baseline and the status sections indicate CCV steelhead and sDPS green sturgeon (*i.e.*, the two species most likely to be impacted by the Project) have experienced considerable declines in abundance and long-term population trends that suggest a negative growth rate. Human-induced factors have reduced populations and degraded habitat, which in turn has reduced the population's resilience to natural events, such as droughts, floods, and variable ocean conditions. Global climate change presents another real threat to the long-term persistence of the population, especially when combined with the current depressed population statuses and human-caused impacts. Within the action area in the Delta, the effects of shoreline development, industrialization, and urbanization are on-going and not likely to be curtailed in the near future. These activities have eliminated tidal marsh habitats, introduced non-native species, degraded water quality, contaminated sediment, and altered the hydrology and fish habitat of the action area. As a result, forage species that listed salmonids and green sturgeon depend on have been reduced; periodic sources of contaminants continue from boats, roadways, stormwater discharge; and natural shoreline habitat areas have been degraded.

Since the proposed bridge construction activities will occur during the August 1 through October 15 period, adult and juvenile CCV steelhead and juvenile sDPS green sturgeon are likely to be present within the action area during pile driving activities. During bridge construction activities, water quality in the action area may be degraded through increased turbidity and suspension of sediment-borne contaminants. Increases in turbidity in the action area will be temporary, confined to Rock Slough, and similar to the natural conditions typically encountered by listed fish in the action area. Underwater sound will be above ambient conditions during pile driving for a distance extending from 1,220 feet (best case) to 7,067 feet (worse case) from the Rock Slough Bridge (187dB zone of potential physical injury). Under the worst case scenario, elevated sound levels could result in a negative behavioral response for a portion of each day during the August 1-October 15 in-water work window of pile driving that would render 123 acres within the action area partially unusable by listed anadromous salmonids and green sturgeon for foraging and migrating. The partial loss of this portion of the action area is a temporary adverse effect because this area provides foraging habitat for listed fish. When the in-water work (21 days of pile driving)has concluded, elevated sound levels within the zone of behavioral effects will cease and listed fish may again access food resources in the action area undisturbed by pile driving. Temporary delays to upstream and downstream passage are expected to occur during daylight hours of pile driving due to underwater noise. However, delays are expected to be temporary and not completely block migrating fish due to breaks in pile driving operations and sound minimization measures. Sound impacts from the bridge construction may reach as far as the portion of Rock Slough that is designated critical habitat. Based on the above impacts, a small number of adult CCV steelhead and green sturgeon found in the south Delta are likely to be adversely affected by the proposed action. However, it is unlikely that the temporary impact of reduced access to food resources during the 2.5-month period will cause individual fish to die. Additionally, this impact is not expected to reduce future adult returns, since the majority of salmonids and sturgeon would be unaffected by the Project due to its location and timing. Therefore, the combined effects of the Project will not lead to any population-scale effects to listed salmonids or green sturgeon.

The action area is designated critical habitat for sDPS green sturgeon and CCV steelhead. Critical habitat is expected to be impacted through temporary degradation of water quality, temporary impacts to foraging habitat, and reduced access to migration corridor during bridge construction. Water quality will be degraded through increased turbidity and suspension of sediment-borne contaminants. Foraging habitat will be temporarily affected during Project construction by physical disturbance of the benthic habitat, elevated contaminants in suspended sediments, and the associated impacts to food resources. Stormwater discharge from future urban development is expected to increase, however, the water quality will be improved over existing conditions, therefore, this is not expected to negatively impact critical habitat. Although there are temporary impacts on critical habitat in the action area, the reduction in water diversion and improvement in water quality is expected to provide long-term benefits to critical habitat in the action area.

Regarding future climate change effects in the action area, California will likely be subject to higher average summer air temperatures, lower total precipitation levels, and higher sea levels with greater salinity in the Delta. This would likely, in turn, reduce the snow pack in the Sierras. Reductions in the amount of snowfall and rainfall would reduce stream flow levels in most Central Valley rivers. The Sacramento-San Joaquin Delta region may also experience changes in productivity due to changes in the quality of freshwater flows, nutrient cycling, and sediment amounts. For this Project, the effects of climate change are not likely to be detected during the bridge construction (August 1 through October 15, 2016), however, could be a factor leading to larger than modeled stormwater releases over the next 84 years. Larger storm events (due to climate change) than modeled could exceed the capacity of the stormwater retention system and cause non-point source pollution from residential developments to enter the waters of Dutch Slough and Sandmound Slough. Non-point source pollution from stormwater runoff has been shown to cause immediate mortality in adult salmon returning to urban streams (Schartz 1985, Sandahl *et al.* 2005, and Spromberg and Scholz 2011). Climate change can lead to more variable weather patterns than historical trends with higher storm peaks and longer droughts. Drought conditions increase stream temperatures and reduce suitable habitat which place further stress on salmonids and green sturgeon populations (*e.g.*, lower returns of salmon in future years). However, salmon and green sturgeon are expected to persist throughout these phenomena, as they have in the past, even when concurrently exposed to the cumulative effects of similar urban development projects like the Cypress Preserve.

The Project is also expected to negatively affect sDPS North American green sturgeon that are migrating through or rearing in Dutch Slough, Sandmound Slough, and Rock Slough. As indicated for salmonids, habitat degradation through declines in water quality parameters and the temporary loss of the food resource PBF will be experienced by green sturgeon within the action area. The greatest impacts experience by green sturgeon will be from underwater noise caused by pile driving. Green sturgeon are expected to avoid the area of construction impacts in Rock Slough and therefore not be physically harmed or killed.

A portion of the action area (*i.e.*, Sandmound Slough, Dutch Slough, and part of Rock Slough) is designated critical habitat for CCV steelhead and sDPS green sturgeon (Table 7). The Central Valley Recovery Plan states that freshwater habitat should be maintained in a non-deteriorating state (NMFS 2014). The benefit of treated stormwater from the conversion of agricultural to urban development must be weighed against the likelihood of an increase in non-point source pollution from future increases in traffic into the action area. Although the critical habitat in the action area will retain its degraded condition as a result of implementing the proposed action, when considered as a whole, it will not appreciably diminish the capability of other waterways in the respective critical habitat ranges to function as migratory corridors or rearing habitat for CCV steelhead and sDPS green sturgeon. Since the largest population segments of these listed species utilize a different river system (*i.e.*, Sacramento River) as their primary migratory corridor to reach the most productive spawning and rearing grounds; degradation of the migratory corridor habitat, water quality PBF, sediment quality PBF, and any temporary loss of food resource PBF in the action area is not likely to appreciably diminish the conservation value of the critical habitat of the two affected populations.

Stormwater discharge is identified as a threat in the Central Valley Recovery Plan (NMFS 2014) within the action area that is used for migration and rearing of CCV steelhead. The present status of the CCV steelhead is that the DPS has improved slightly, but still considered at high risk of extinction (Williams *et. al.* 2016). Our analysis indicates that the proposed Project is likely to temporarily reduce rearing opportunity for individuals in the action area, but not to the extent that would reduce the population's ability to achieve and maintain its viability criteria, and thus contribute to species-level recovery. Therefore, the effects of the Project are not likely to appreciably reduce the species' likelihood of survival and recovery, even though the Central Valley Recovery Plan identified this type of activity as a threat.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CCV steelhead and the Southern DPS of North American green sturgeon, or destroy or adversely modify designated critical habitat for CCV steelhead, and the Southern DPS of North American green sturgeon.

2.8 Incidental Take Statement

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

2.8.1 Amount or Extent of Take

In this opinion, NMFS determined that incidental take would occur in the form of death, injury, harassment, and harm from pile driving, increased turbidity, resuspended sediments, and stormwater discharges. NMFS also anticipates that take of threatened CCV steelhead and threatened Southern DPS of North American green sturgeon associated with the construction of the Rock Slough Bridge will be in the form of temporary partial loss of foraging habitat for a distance of 1,220 to 7,067 feet in Rock Slough (or 26 to 123 acres) during 21 days of in-water work from August 1 through October 15, 2016. The use of benthic habitat by green sturgeon for feeding and rearing within the action area is expected to increase their vulnerability to noise impacts compared to salmonids which are migrating through the action area within hours or days.

The numbers of steelhead and green sturgeon that could be taken is difficult to quantify because dead and injured individuals are difficult to detect and recover. Monitoring or measuring the number of listed fish actually harmed by an adverse behavioral response to elevated sound levels and associated reduction in foraging opportunities during pile driving is not possible. The harm associated with these elevated sound levels is generally sublethal and generally undetectable. Due to the difficulty in quantifying the number of listed fish that could be affected during the 76-day period, a surrogate measure of take is necessary to establish a limit to the take exempted by this incidental take statement. For this action, compliance with the expected elevated underwater sound levels during pile driving is the best surrogate measure for incidental take associated with Project implementation. Therefore, NMFS considers the extent of take exceeded, if sound pressure levels rise above the following levels during pile driving:

a) 206 dB maximum peak at a distance of 30 feet from any piles,
b) 187 dB cumulative SEL at a distance of 1,220 feet for 24-inch diameter piles,
c) 187 dB cumulative SEL at a distance of 7,067 feet for 48-inch diameter piles,
d) 150 dB RMS at a distance of 13,061 feet for 24-inch diameter piles, and
e) 150 dB RMS at a distance of 32,808 feet for 48-inch diameter piles.

Incidental take is expected to include the following:

1. Within Rock Slough, physical injury and altered fish behavior causing delayed migration, reduced foraging, or greater predation, resulting from acoustic impacts from 150 dB–187 dB, which NMFS considers the threshold of behavioral and physiological changes in exposed fish species. Based on fish monitoring data near the action area (*i.e.*, Fish Salvage Facilities), during the construction period (August 1–October 15), NMFS expects that a small number of CCV steelhead and sDPS green sturgeon will be present during the pile driving activity. NMFS estimates that no more than 1 juvenile or adult steelhead and 1 juvenile or adult sDPS green sturgeon will be incidentally taken during the August 1 through October 15 work

window. Most adult CCV steelhead in the Sacramento River move upstream in September, but on the San Joaquin River upstream migration peaks later in December (Table 4).

2. Altered habitat conditions caused by pile driving, removal of piles, and in-water construction include loss of benthic organism diversity (0.002 acre from piles), loss of riparian and shallow water habitat (0.22 acre from bridge shading), and increased predation risks. Permanent loss of non-critical habitat is not expected to exceed 55.9 cubic yards of water column habitat displaced by the concrete bridge piles. Temporary loss during bridge construction is not expected to exceed 123 acres (*i.e.*, worse-case scenario for pile driving).

3. Incidental take, in the form of harm and harassment related to turbidity and suspended contaminants in sediments is expected to be similar to the take associated with acoustic and habitat effects. The same individuals exposed to sound impacts > 150 dB would be exposed to these impacts. Therefore, incidental take of CCV steelhead and sDPS is not expected to exceed 1 juvenile or 1 adult of each species.

The estimated incidental take using elevated underwater sound levels during pile driving as a surrogate for ESA-listed fish species (fish > 2 grams) from the modeled calculations for the Rock Slough Bridge (Reclamation 2016). Distances are measured for worst-case scenarios depending on type of pile driving.

Type of Incidental Take	Sound Level (decibels)	Distance from piles (feet)	Habitat (acres)
Mortality	206	30	0.11
Physical Effects	187	7,067	26.6
Behavioral Effects	150	32,808	123.5

2.8.2 Effect of the Take

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

2.8.3 Reasonable and Prudent Measures

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

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize the extent of incidental take of CCV steelhead and sDPS green sturgeon.

1. Measures shall be taken to avoid, minimize, and monitor the impacts of pile driving and bridge construction on listed steelhead, green sturgeon, and their critical habitats.

2. Measures shall be taken to avoid, minimize, and monitor the adverse effects of underwater noise on listed steelhead, green sturgeon, and their critical habitats.

3. Measures shall be taken to avoid, minimize, and monitor the adverse effects of stormwater discharge from residential development within the Project on listed steelhead, green sturgeon, and their critical habitats.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation or any applicant, must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Reclamation, 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: Measures shall be taken to avoid, minimize, and monitor the impacts of the Project during pile driving and bridge construction upon listed steelhead, green sturgeon, and their habitats.

a) Reclamation, or its contractor, shall monitor water quality adjacent to the Rock Slough Bridge within 7,067 feet (or to the Delta Road Bridge) for any affected fish including, but not limited to Chinook salmon, CCV steelhead, or sDPS green sturgeon. This monitoring shall be conducted by a trained fishery biologist and will include turbidity monitoring and visual observations during the in-water construction. If any Chinook salmon, steelhead, or sturgeon are observed being affected by the construction during the monitoring, the Project applicant must cease in-water activities and notify NMFS within 24 hours of the incident.

   Attn: Assistant Regional Administrator
   National Marine Fisheries Service
   650 Capitol Mall, Suite 5-100
   Sacramento, California 95814-4706

   Office: (916) 930-3600
   Fax: (916) 930-3629

   The Project applicant shall coordinate with NMFS to determine the cause of the take and whether any additional protective measures are necessary to protect CCV steelhead or sDPS green sturgeon. Any additional protective measures shall be implemented as soon as possible and within 72 hours of the incident. Affected fish include those that are:

   (1) dead or moribund;
   (2) showing signs of erratic swimming behavior or other obvious signs of distress;
   (3) gasping at the surface; or
   (4) showing signs of other unusual behavior.

2. The following terms and conditions implement reasonable and prudent measure 2: Measures shall be taken to avoid, minimize, and monitor the adverse effects of underwater noise originating from the Project site upon listed steelhead, green sturgeon, and their critical habitats.

a) Reclamation, or its contractor, shall prepare a sound monitoring plan and submit it to NMFS before construction begins and monitor noise levels during pile driving to ensure that sound levels do not exceed authorized levels.
b) Reclamation, or its contractor, shall minimize sound impacts by using the best case scenario procedures first, as modeled (*e.g.,* use of vibratory hammer until the pile hits hard substrate that requires an impact hammer).
c) Reclamation, or its contractor, shall make available to NMFS data from the sound monitoring on a real-time basis (*i.e.*, daily monitoring data should be accessible to NMFS upon request).
d) Underwater sound monitoring shall be conducted by a qualified biologist during pile driving activities. Accumulated sound exposure levels (SEL) shall not exceed the levels permitted by NMFS and the USFWS (Fisheries Hydroacoustic Working Group 2013). If the sound levels are exceeded, pile driving shall cease. All incidents of exceedance of the SEL standards shall be reported to NMFS within 24 hours. The biologist shall also monitor the site for injury or mortality of listed fish. Any injured or dead fish shall be reported to NMFS within 24 hours.

3. The following terms and conditions implement reasonable and prudent measure 3: Measures shall be taken to avoid, minimize, and monitor the adverse effects of stormwater discharge from residential developments within the Project on listed salmonids, green sturgeon, and their critical habitats.

a) Each developer within the Cypress Preserve Project shall at a minimum meet the requirements of the Contra Costa Stormwater Management Plan to control runoff and pollution from entering the waters of the Delta.

b) Reclamation, or its contractor, shall adhere to the RWQCB General Order No. R5-2009-0085 concerning discharge and turbidity criteria. Copies of any sediment, effluent, or water quality monitoring reports required by the CVRWQCB that are related to the in-water work associated with this Project shall be sent to NMFS at the address above within 60 days of their completion.

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). The measures described below would increase the value of critical habitat and help recover ESA species pursuant to the Central Valley Recovery Plan (NMFS 2014).

1. Reclamation and the Corps should support and promote aquatic and riparian habitat restoration within the Delta region pursuant to the actions identified in the Central Valley Recovery Plan (NMFS 2014). One way to achieve this is by providing incentives to applicants to modify operation and maintenance procedures under the agencies authorities in order to avoid or minimize negative impacts to steelhead and sturgeon in this region.

2. Reclamation and the Corps, through their permitting authority, should support the development of a Comprehensive Stormwater Management Strategy for all residential and commercial developments within the Project that includes a hierarchy of appropriate BMPs as recommended in the Preliminary Stormwater Control Plan (Reclamation 2016, Appendix C).

3. Reclamation and the Corps should provide funding to support anadromous salmonid and sturgeon monitoring programs throughout the Sacramento River, San Joaquin River, and Delta region to improve the understanding of migration and habitat utilization by salmonids in this region.

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

2.10 Reinitiation of Consultation

This concludes formal consultation for the East Cypress Preserve 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 (*e.g.*, sound levels during pile driving exceeding a maximum peak of 206 dB at a distance of 10 m, 187 dB SEL at a distance of 160 m, and 150 dB RMS at a distance of 1,970 m), (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.11 "Not likely to Adversely" Affect Determinations

NMFS does not anticipate the proposed action will take Sacramento River winter-run Chinook salmon or Central Valley spring-run Chinook salmon due to the timing and location of the Project. Individual fish could enter the action area, however, due to the timing and location of the Project, winter-run and spring-run juveniles and adults are not likely to be present during the construction phase (August 1–October 15). The construction of the Rock Slough Bridge contains measures to ensure that potential effects from construction are minimized. A sound monitoring plan will monitor noise levels during pile driving to ensure that sound levels do not exceed authorized levels specified in section 2.8.1 (above). Since a system of retention lakes will treat stormwater before it is released, the impact of these releases will be insignificant (not expected to enter the sloughs within the action area).

Effects of increased sound and turbidity, and resuspension of sediment from construction of the Rock Slough Bridge will be temporary and localized. No direct or indirect effects from the proposed Project's periodic release of treated stormwater entering Dutch Slough and Sandmound Slough are expected. Results of modeling provided in the preliminary stormwater plan demonstrate that there would be no overall increase in the discharge rate arriving at the RD799 pump stations, and that there would be no adverse erosion or sedimentation in the sloughs' channels if the peak pumping rate is kept at or below existing rates.

The permanent loss of 100.5 square feet (0.002 acre) of benthic habitat from the permanent bridge piles and the degradation of 9,565 square foot (0.22 acre) of habitat by shading from the bridge is discountable because winter-run and spring-run are not likely to be present in the action area. The effects of construction of the Rock Slough Bridge and the permanent loss of a small amount of benthic habitat (0.002 acre) and water column habitat (55.9 cubic yards) are discountable for the same reason. The effects of the periodic release of stormwater are insignificant, because the stormwater will be treated through retention lakes and any effect is not expected to rise to the level resulting in take. Therefore, the proposed Project is not likely to adversely affect winter-run or spring-run Chinook salmon.

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 in the BA (Reclamation 2016) and descriptions of EFH developed by the Pacific Fishery Management Council (PFMC) for Pacific coast salmon (PFMC 1999, 2014), Pacific coast groundfish (PFMC 2005), and coastal pelagic species (PFMC 1998), contained in fishery management plans (FMPs) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

Effects of the Project will impact EFH for various Federally-managed fish species within the Pacific Coast Groundfish FMP (PFMC 2005), Pacific Coast Salmon FMP (PFMC 2014), and Coastal Pelagic Species FMP (PFMC 1998). Furthermore, a portion of the action area (Dutch Slough) is located in an estuarine habitat area of particular concern (HAPC) for Pacific salmon, groundfish, and coastal pelagic species Federally managed within the FMPs (see Amendment 18, PFMC 2014; and Appendix A, Figures 1 and 2.

The Pacific Coast Groundfish FMP includes 90-plus species over a large and ecologically diverse area (PFMC 2005). EFH for Pacific coast groundfish is defined as the aquatic habitat necessary to allow for groundfish production to support long-term sustainable fisheries for groundfish and a healthy ecosystem. Within the Delta, EFH for groundfish include all waters from the high water line, and the upriver extent of saltwater intrusion in river mouths along the coast from Washington to California.

The coastal pelagic species fishery includes four finfish Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber australasicus*), northern anchovy (*Engraulis mordax*), and jack mackerel (*Trachurus symmetricus*); along with invertebrates, market squid (*Loligo opalescens*) and all krill (*Euphausiacea* spp) species that occur within the U.S. West Coast exclusive economic zone (EEZ, PFMC 1998). EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 50°F to 79°F (10°C to 26°C, PFMC 1998). The Coastal Pelagic Species FMP also includes two ecosystem component species: jacksmelt (*Atherinopsis californiensis*) and Pacific herring (*Clupea pallasii*).

For the Pacific coast salmon, the PFMC (2014) has identified and updated the description of EFH, adverse impacts, and recommended conservation measures for salmon. Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem (Appendix A, Figure 3) as described in NMFS (2011a, c), and includes the San Joaquin Delta hydrologic unit (*i.e.*, number 18040003). This includes all the waters surrounding the Project action area (*i.e.*, Dutch, Sandmound, and Rock Sloughs). Winter-run (*Oncorhynchus tshawytscha*), spring-run (*O. tshawytscha*), and CV fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Pacific Coast Salmon FMP that occur within the Delta hydrologic unit.

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) also recommend that HAPCs be identified, if present. The PFMC has designated the following five HAPCs: 1) complex channels and floodplain habitats; 2) thermal refugia; 3) spawning habitat; 4) estuaries; and 5) marine and estuarine submerged aquatic vegetation. The landward extent of the estuary HAPC is defined by the upstream extent of salt water intrusion at 0.5 ppt (Appendix A, Figure 2). The estuary HAPC for the Delta extends from Big Break into Dutch Slough up to the confluence with Taylor Slough (between Jersey and Bethel Islands), which includes a portion of the action area. Within the Project, stormwater releases enter Dutch Slough from pump station 2. Therefore, NMFS has determined that within the action area the estuary HAPC is present for all three FMPs.

Factors limiting salmon populations in the Delta include reversed flows, loss of fish into unscreened agricultural diversions, predation, and reduction in the quality and quantity of rearing habitat due to channelization, pile driving, urbanization, stormwater discharge, rip-rapping, *etc.* (Dettman *et al.* 1987; Kondolf *et al.* 1996a, 1996b, NMFS 2014). Loss of vital wetland habitat along the fringes of the San Francisco and Suisun bays reduce rearing habitat and diminish the functional processes that wetlands provide for the bay ecosystem.

A. Life History and Habitat Requirements

1. Coastal Pelagics

The habitat in the action area is unique in that it contains both freshwater and saltwater fish species that depend on the large tidal mixing zone for foraging, shelter, and as a nursery. EFH species such as Pacific herring and jacksmelt can utilize the Dutch Slough portion of the action area for a part of their early life history before migrating to the ocean. Within the action area, Pacific herring were observed at the Rock Slough Headworks from 1999–2011 (Table 5, Reclamation 2016).

a. Pacific sardine are small (<16 inches), pelagic, fish in the herring family that form large schools offshore. They are found along the Pacific coast from Guaymas, Mexico to Kamchatka, Russia (Miller and Lea 1972). Typically found with jack mackerel, Pacific mackerel, and northern anchovy during the day, they disperse at night. Pacific sardine can live 13-25 years, although most captured in California are less than 5 years of age. Sardines are batch spawners, releasing about 9,000 – 100,000 eggs at a time and spawn between February and August off the California coast (PFMC 2013). As juveniles and sub adults, sardines reside primarily nearshore, but as they grow older and larger they move further offshore and migrate north to feed. Pacific sardine are filter feeders and prey on crustaceans, copepods, fish larvae and phytoplankton. Larval sardines feed extensively on the eggs, larvae, and juvenile stages of copepods, as well as other zooplankton and phytoplankton (PFMC 2013). Pacific sardine support an important commercial fishery in California and are a one of the most abundant forage species for other fish, birds, and mammals. Sardine populations are subject to natural fluctuations dependent on ocean conditions. Commercial landings of Pacific sardine have plummeted from a high of 127,000 metric tons in 2007, to a complete ban on fishing in 2016. No observations of pacific sardine were reported in any of the CDFW fish monitoring surveys (Reclamation 2016).

b. Pacific mackerel, or blue mackerel, are a torpedo-shaped fish similar to tuna, but in the Mackerel family (*Scombridae*). They are a fast moving, schooling fish, distributed across the Pacific Ocean from California to Australia in surface waters to 660 feet. Ranging in size from 12 to 25.5 inches and weighing up to a little over 2.2 lbs, they tend to stay in areas within a few degrees of 50°F in tropical to subtropical waters (Audubon 2002). Along the Pacific Coast, they are found from Monterey Bay south to Baja California, being most abundant south of Point Conception. Pacific mackerel can live up to 7 years, but are most commonly found to be 1–3 years of age. They are carnivores, eating smaller fish, plankton, and krill. They spawn in the open ocean and incubation periods range from 3–8 days depending on temperature. Commercial landings in the U.S. have declined from a peak of 70,000 metric tons in 1990 to 10,000 metric tons in 2014 (Crone and Hill 2015). This species is managed by the PFMC using harvest control rules based on the stock biomass under the FMP. It does not occur in the Delta. No observations of Pacific mackerel have been reported in CDFW fish monitoring surveys (Reclamation 2016).

c. Jack mackerel are long fusiform shaped, silvery, fish (to 31 inches) in the Jack family (*Perciformes*). They are pelagic, being found offshore from Alaska to Ecuador. Jack mackerel are important commercially in Southern California. They feed on krill, squid, anchovies, and lanternfish. Large schools of these fish provide a major food source for seals, sea lions, porpoises, swordfishes, sea basses, and pelicans (Audubon 2002). No observations of Jack mackerel were reported in any of the CDFW fish monitoring surveys in the Delta (Reclamation 2016).

d. Jacksmelt are small (<15 inches), fusiform shaped, greenish-blue fish in the Silverside family (*Atherinidae*). They are common in schools throughout the inshore surface waters and in bays from Baja California to Oregon (Miller and Lea 1972). Jacksmelt can live 8-9 years and feed on small crustaceans. Jacksmelt are typically found in San Francisco Bay where salinities are > 30 ppt. Similar to topsmelt and California grunion, Jacksmelt mature in 2-3 years and spawn during the late winter and spring. The large eggs are attached to kelp and other algae. Topsmelt and jacksmelt are caught by recreational anglers from piers. The annual commercial harvest of both species in California totals about 250 tons (Audubon 2002). In the Delta, juvenile Jacksmelt (age-0) have been observed in Franks Tract and near Jersey Island (San Joaquin River) during CDFW surveys.

e. Pacific herring are small (< 18 inches), short-lived, fish typically found in large schools near inshore waters from the Gulf of Alaska to Baja California (Audubon 2002). They are an important commercially being used for bait, oil, and food products. They are also a key prey species for larger species like salmon and whales. Pacific herring spawn during winter and early spring inside bays on rocks and kelp. Their eggs or roe are harvested commercially in San Francisco Bay and exported to Japan. The eggs hatch within 10 days and can drift with the tides into the Delta. Larval herring migrate from the south and central portions of San Francisco Bay into the Suisun Bay to rear in years when salinity is high (IEP 2014). Within the Delta, juvenile Pacific herring have been observed in Franks Tract and near Jersey Island (San Joaquin River) during CDFW surveys.

f. Northern anchovy are small, short-lived, fish typically found in schools near the water surface. They spawn in every month of the year, but spawning increases during late winter and early spring (Moyle 2002). This species is a broadcast spawner and females can produce up to 30,000 eggs a year. The San Francisco Bay and Delta provide favorable reproductive habitat because abundant food exists for both adults and larvae.

Anchovies feed diurnally by filter feeding. All life stages of northern anchovy are important prey for predatory fish, birds, and mammals, including Chinook salmon, seals, and sea lions. Northern anchovy do not typically inhabit the action area due to the low salinity found there (< 0.5 ppt). No observations of northern anchovy were reported in any of the fish monitoring surveys (Reclamation 2016).

2. Pacific Groundfish

Starry flounder (*Platichthys stellatus*) is the most abundant Pacific groundfish species within the action area. They are flatfish with both eyes on the upper side of the body, which prefers brackish water (average size 35–41 cm, maximum 91 cm). Most spawning occurs in shallow water near the mouths of rivers and estuaries during the winter (Moyle 2002). They are most commonly found on mud, sand, or gravel bottoms near shore and often enter brackish or fresh water. An average size female can produce about 11 million eggs per season. In California, starry flounder spawn from November to February with the peak months in December and January. Starry flounder larvae and juveniles are eaten by larger fish, wading birds, and marine mammals. Starry flounder were observed in every year near the action area during CDFW's Bay Study otter trawl surveys at stations 837 and 853 from 2009–2013 (Appendix A, Figure 4). The most recent stock assessment for the West Coast showed that catch rates in California have been declining since the 1970s (Ralston 2005).

3. Pacific Salmon

General life history information for CV Chinook salmon is summarized below. Further detailed information on winter-run and spring-run are available in the status of the species section (Section 2.2) of this Opinion.

Adult CV fall-run Chinook salmon typically enter the Sacramento and San Joaquin rivers from July through December and spawn from October through December (USFWS 1995). Late fall-run Chinook salmon migrate into the rivers from mid-October through mid-April and spawn from January through mid-April. Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (Ford 2011).

Fall-run and late fall-run egg incubation occurs from October through April (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genae 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time (3 days to 3 months) in the Delta and estuary before entry into the ocean. Whether entering the Delta as fry or juveniles, CV Chinook salmon depend on migratory passage through the Delta for access to the ocean.

Juvenile Chinook salmon (not identified to run) were observed in CDFW's Bay Study otter trawl and midwater trawl from 2009–2013 at stations 837 and 853 (Appendix A, Figure 4) near the action area (Reclamation 2016). Within the action area, juvenile fall-run, spring-run, and unidentified Chinook salmon were observed at the Rock Slough Headworks (prior to construction of the Rock Slough Fish Screen) from 1999–2011 (Table 5 in Reclamation 2016). Adult fall-run Chinook salmon (n=39) were recovered from the Rock Slough Fish Screen in 2011 and 2012 (Table A-4 in Reclamation 2016). These fish were observed from November through December and were mainly adults returning from the juveniles released from the Mokelumne River Fish Hatchery at Sherman Island.

3.2 Adverse Effects on Essential Fish Habitat

Based on the best available information, the proposed Project would adversely affect EFH for Pacific salmon for 21 days from August 1 through October 15. Adverse effects to EFH will occur through: (1) construction of the Rock Slough Bridge that will result in increased turbidity, increased sound from pile driving, resuspension of sediments, degradation of aquatic habitat, and loss of habitat; and (2) release of treated stormwater that could result in increased contaminants and increased turbidity over the life of the Project from residential development.

The effects of the proposed action on salmonid habitat are described in detail in Section 2.4 (*Effects of the Action*), and generally are expected to apply to Pacific salmon EFH. The Project's in-water work window (August 1–October 15) is likely to occur when adult fall-run Chinook salmon start to migrate upstream in October. The majority of effects from the Project (*e.g.*, underwater sound, resuspension of sediments, increased turbidity, stormwater discharges, and loss of habitat) will only temporarily degrade the quality of freshwater and estuarine EFH in the Delta. The permanent loss of 100.5 square feet (0.002 acre) of benthic habitat and 55.9 cubic yards of water column habitat from the addition of bridge piles and the shading from the bridge (0.22 acre) have been fully mitigated through the purchase of three mitigation credits at the Kimball Island Mitigation Bank.

Pile driving has been specifically identified in Amendment 18 to the Pacific Coast Salmon FMP as a source of impacts on salmon EFH (PFMC 2014). Pile driving may adversely affect infaunal and bottom-dwelling organisms at the site by removing immobile organisms such as polychaete worms and other prey types or forcing mobile animals such as fish to migrate to other areas. Benthic plants and animals from the surrounding undisturbed areas are likely to re-colonize sediments within a few days of completion of the Project.

The effect of the proposed action on Pacific groundfish and coastal pelagics is similar to those listed above for Pacific salmon with the exception of sound effects. Since larvae and eggs of Pacific groundfish and coastal pelagics can be < 2 g within the action area the lower threshold (183 dB) for sound impacts from pile driving would apply. This means that a larger area for physical injury would occur for EFH species than for salmon (*i.e.*, 2,254–7,067 feet for the worse-case scenario). The larger area of aquatic habitat in Rock Slough temporarily impacted by pile driving represents 123 acres (Reclamation 2016).

Pile driving at the Rock Slough Bridge will impact forage species, such as infaunal and bottom-dwelling organisms like polychaete worms and crustaceans, by directly removing or burying these organisms. Recolonization studies suggest that recovery may not be linear, and depends on physical factors such as particle size distribution, currents, and stabilization processes following disturbance. Rates of recovery listed in the literature range from several months to several years for estuarine muds and can take up to 1 to 3 years in areas of strong currents (Oliver *et al.* 1977, Currie and Parry 1996, Watling *et al.* 2001). However, the habitat in Rock Slough is dominated by tidal exchange of typically from 1 to 4 feet with a range of +8.0 feet to – 1.6 feet (Reclamation 2012). Velocities measured at the Rock Slough Fish Screen varied from 0 to 0.40 feet/second depending on the tides, with a daily average of 0.14 feet/second (Reclamation 2012). Due to the water velocities and tidal action, recolonization of benthic organisms is likely to occur within days.

The act of removing soft-bottom sediments and their associated biotic assemblages during pile driving creates an area of disturbance, which is extremely susceptible to recolonization by invasive species, often resulting in the displacement of native species. As a result, pile driving and removal can increase the distribution and abundance of existing invasive species in the Delta. Introduced organisms increase competition with indigenous species or forage on indigenous species, which can reduce fish and shellfish populations. The introduction of exotic organisms could lead to changes in relative abundances of species and individuals that are native and important forage species.

An increase in impervious surfaces within the Project's proposed urban development has generally been found to increase the rate of stormwater runoff (Balanced Hydrologics 2015). Contaminants from driveways, roads, and parking lots contribute petroleum products and heavy metals to storm runoff and can degrade water quality in Dutch Slough and Sandmound Slough. Juvenile herring were found to avoid areas that have increased turbidity (Corps 2004). Pesticides and fertilizers applied to residential, commercial, and recreational (parks) landscaping are likely to be mobilized by storms and transported to the Delta through a network of interior ditches, potentially impacting aquatic life and adjacent riparian vegetation. The discharge of stormwater will result in direct effects to EFH species and the quality of habitat.

Control of stormwater runoff is currently regulated by the CVRWQCB, through issuance of a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit is monitored through the City of Oakley and the Contra Costa County Clean Water Program. The Project's design and Stormwater Management Plan will mitigate for potential impacts to Dutch Slough EFH from increased runoff and increased contaminants. The Project contains enough open space and separation between impervious surfaces that allow infiltration to occur. A system of lakes will retain water for a minimum of 48 hours to enhance sediment removal, biological uptake, photodegradation, and other pollutant removal mechanisms. The lakes include aeration, circulation, and filtration systems to provide control of nutrient and algal growth (Balanced Hydrologics 2015). The water quality entering Dutch Slough will be significantly improved due to the Project compared to the current non-treated condition. Modeling results indicate that there will be no increase in erosion, sedimentation, or discharge rate as a result of increased stormwater runoff (Reclamation 2016).

3.3 Essential Fish Habitat Conservation Recommendations

Term and condition 3a (*i.e.*, compliance with the Contra Costa County Clean Water Program) from this biological opinion shall serve as an EFH Conservation Recommendation covering stormwater discharges for Pacific coast salmon, Pacific groundfish, and coastal pelagic species. In addition, the following EFH Conservation Recommendations should to be implemented in the action area for Pacific coast salmon, Pacific groundfish, and coastal pelagics as provided below. To promote recovery of Chinook salmon and minimize the adverse effects resulting from the Project, NMFS is including the following actions from the Central Valley Recovery Plan (NMFS 2014) as EFH Conservation Recommendations. Fully implementing these Conservation Recommendations would minimize the adverse effects to EFH that are within the action area (*i.e.*, EFH for Pacific coast salmon in the action area includes Rock Slough, Sandmound Slough, and Dutch Slough; Figure 4).

3.3.1 Pile Driving and Associated Activities

In order to minimize adverse effects to the migratory corridors within the south Delta portion of the action area, caused by pile driving, pile removal, or bridge construction, Reclamation, the Corps, and ACD-TI, LLC (applicant) should:

(1) Maintain riparian habitat of appropriate width for Pacific coast salmon (defined as mean higher high water in tidal areas) in Rock Slough that influences the estuary HAPC within the Delta EFH;

(2) Reduce erosion and runoff from the Rock Slough Bridge construction site into the waterways within the action area.

(3) NMFS 2014 Delta Recovery Action 1.6: Provide access to new floodplain habitat in the South Delta for migrating salmonids from the San Joaquin system.

(4) NMFS 2014 Delta Recovery Actions 1.7: Implement the Dutch Slough Tidal Marsh Restoration Project.

3.3.2 Water Quality Impacts

Water quality essential to salmon EFH can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, or when deposited contaminants in the sediments are resuspended. Indirect sources of water pollution in salmon EFH includes stormwater discharge from impervious surfaces, agricultural areas, and residential developments. In order to minimize these impacts, Reclamation, the Corps, and/or its applicant should:

(1) Provide copies of any sediment, effluent, or water quality monitoring reports pre and post construction required by the CVRWQCB that are related to the in-water work associated with this Project. Reports should be sent to NMFS at the address above within 60 days of completion of the Project.

(2) Implement projects that improve stormwater treatment in residential and commercial areas throughout the Delta (NMFS 2014, Delta Recovery Action 2.20).
(3) Ensure that non-point pollution from the Cypress Preserve development does not enter Dutch Slough or Sandmound Slough from stormwater releases.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, approximately 345 acres of designated EFH for Pacific coast salmon, of which, 139 acres is HAPC for Pacific coast groundfish, and coastal pelagic species.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this Opinion is Reclamation. Other interested users include the applicant (ACD-TI Oakley, LLC), the Corps, USFWS, CDFW, the CVRWQCB, the City of Oakley, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this Opinion were provided to Reclamation and the Corps. This Opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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6. APPENDIX A (Figures)

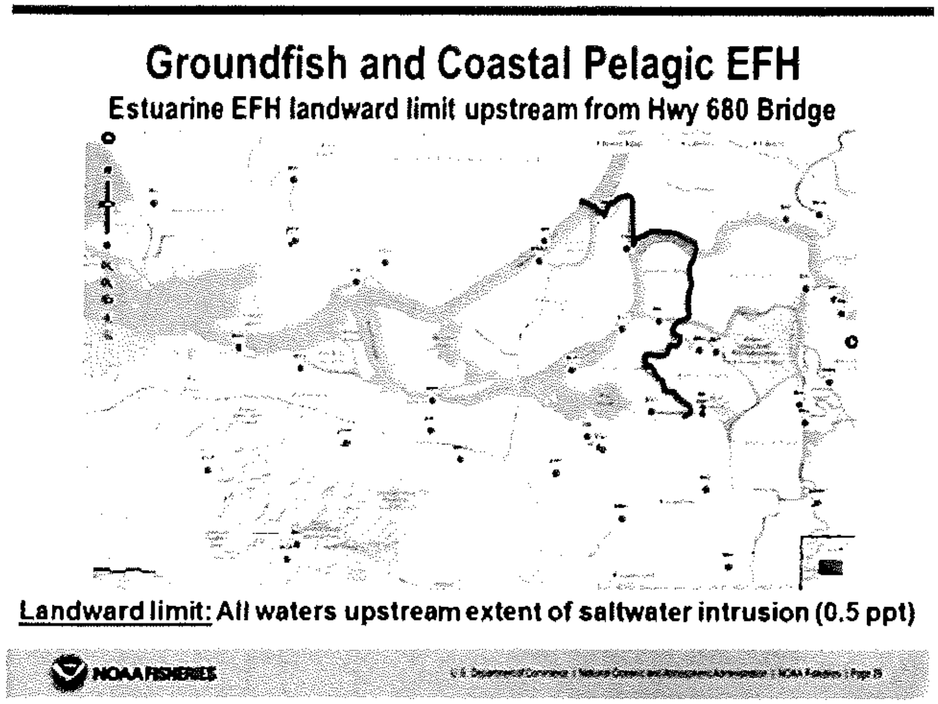

Figure 1. Extent of Essential Fish Habitat for Groundfish, Coastal Pelagics (PFMC 2014).

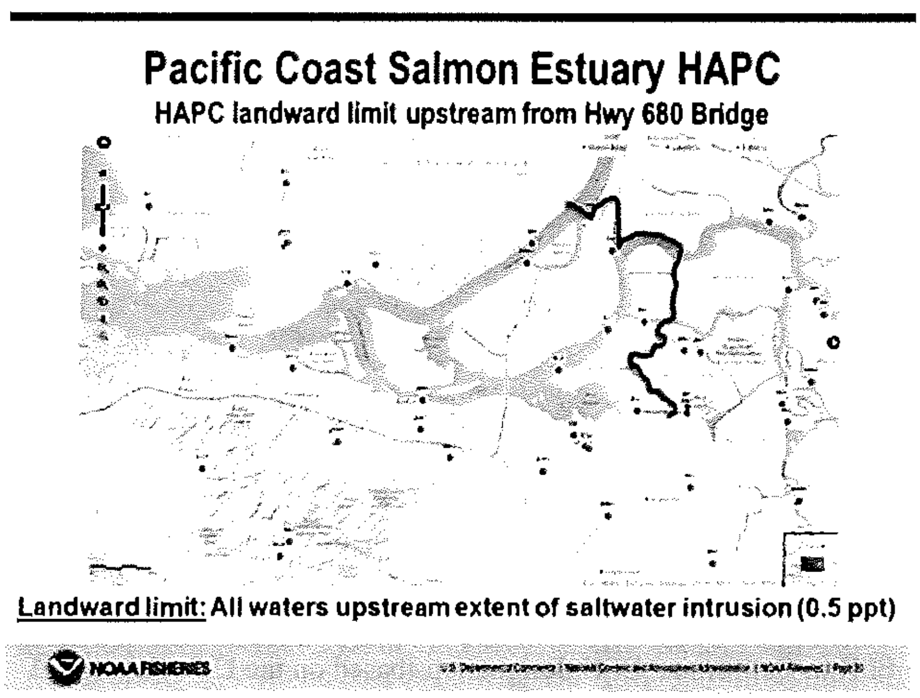

Figure 2. Habitat Area of Particular Concern (HAPC) for Pacific Salmon (PFMC 2014).

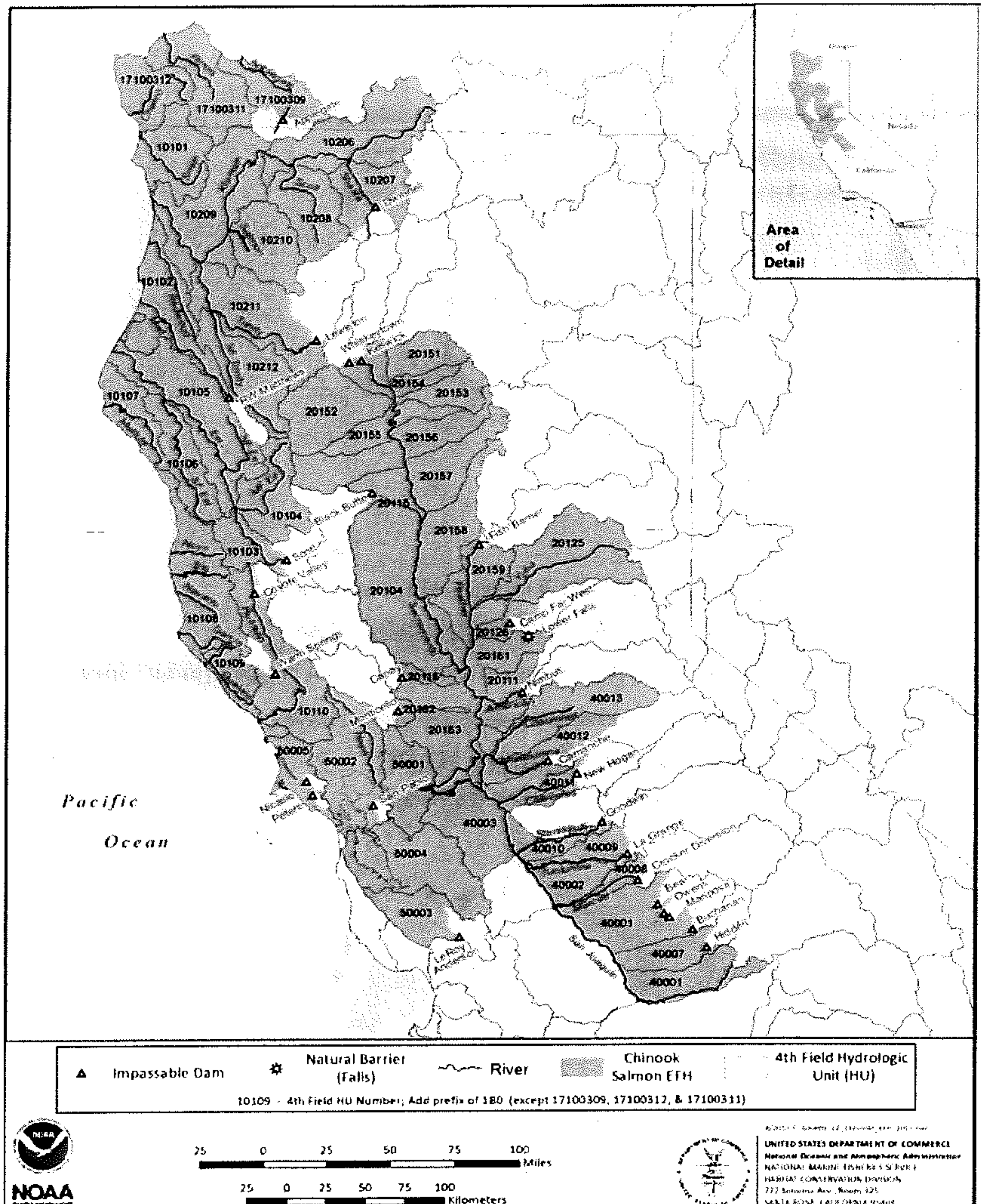

Figure 3. Chinook salmon EFH in California. EFH designations based on the U.S. Geological Survey, 4th field hydrologic units (source: PFMC 2014, Appendix A).

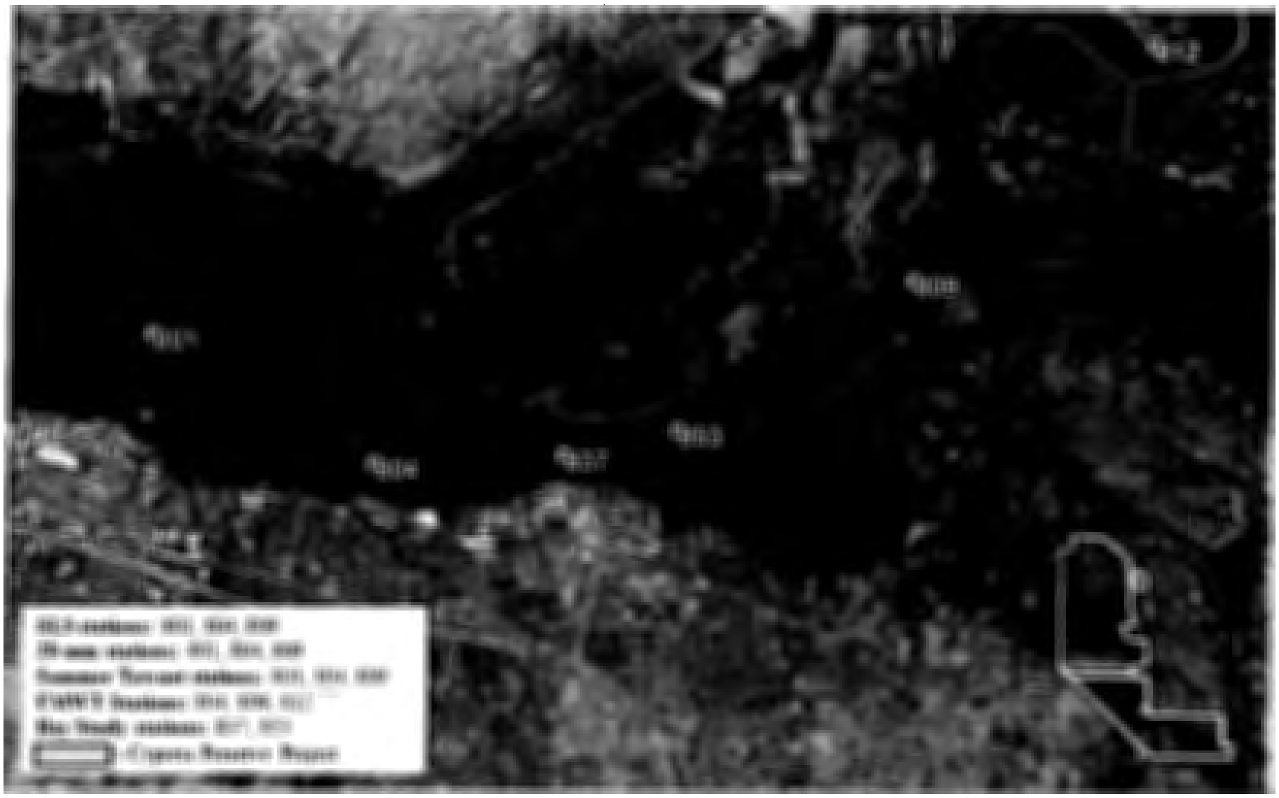

Figure 4. Location of CDFW sampling stations in relation to the Cypress Preserve Project.

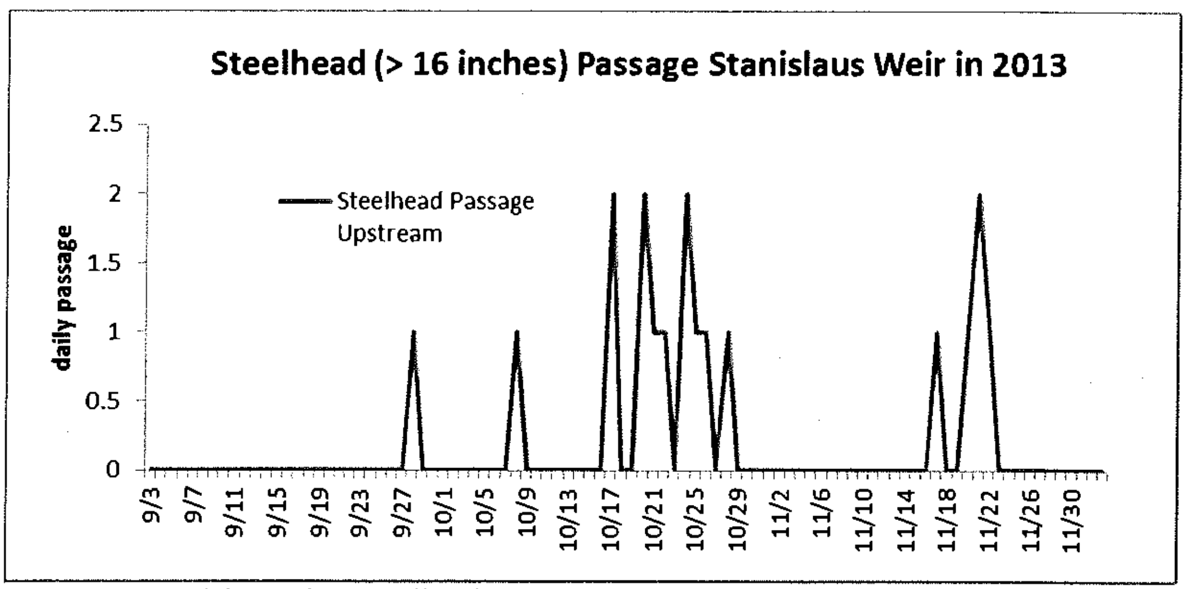

Figure 5. Stanislaus River steelhead returns by date in 2013 (n=18), source: FishBio 2014.

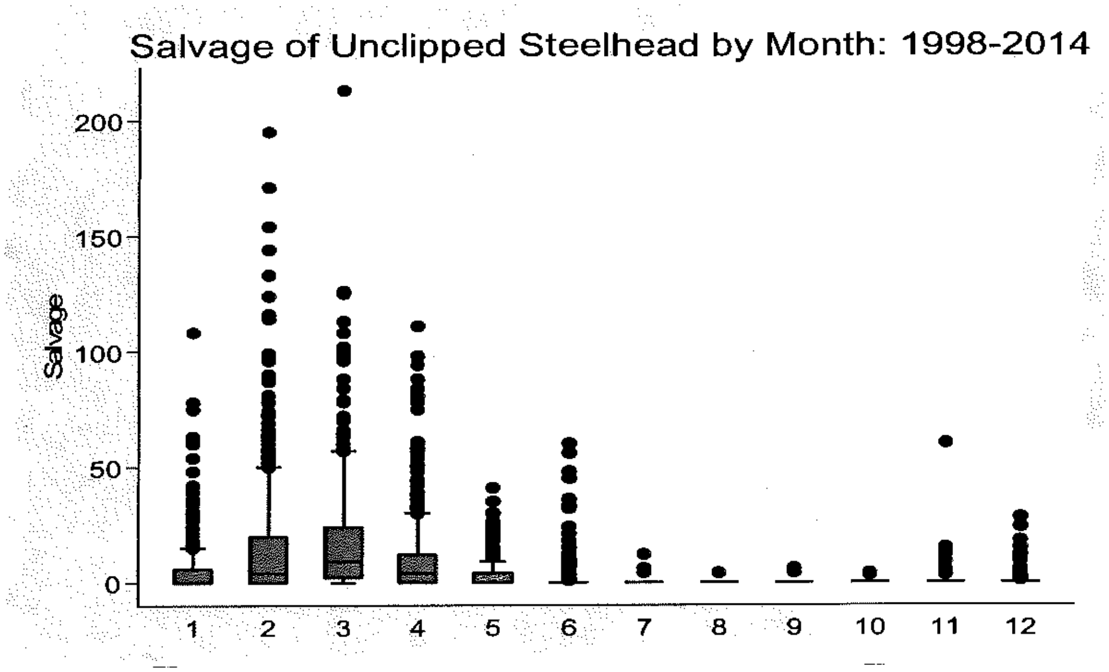

Figure 6. Steelhead (unclipped) salvage by month at the State and Federal Delta Fish Facilities 1994–2014. (CDFW 2016, unpublished data)

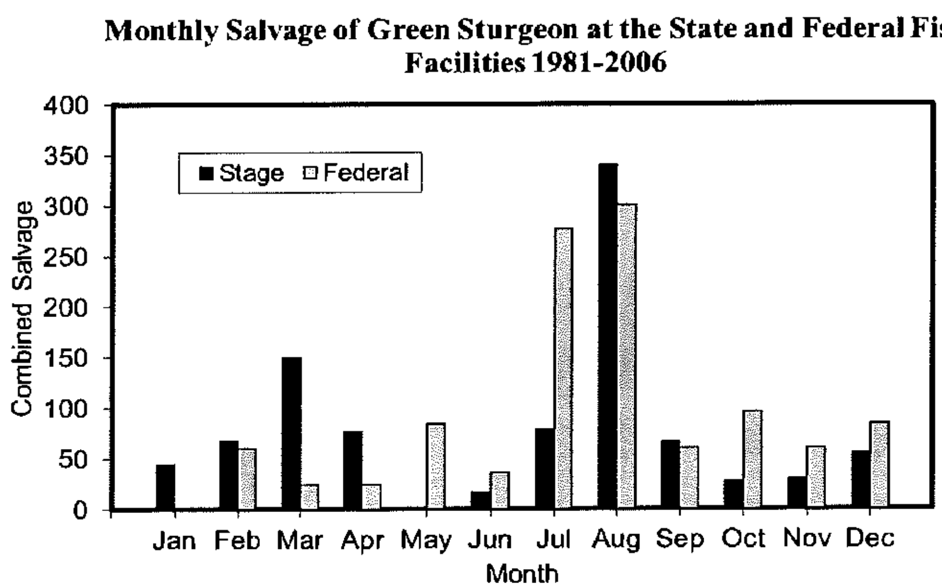

Figure 7. Green sturgeon salvage by month at the State and Federal Fish Facilities 1981–2006. (CDFW 2016, unpublished data)