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

OCT 3 2016

Refer to NMFS No: WCR-2015-5673

Anastasia T. Leigh
Regional Environmental Officer
U.S. Department of Interior
Bureau of Reclamation, Mid-Pacific Regional Office
2800 Cottage Way
Sacramento, California 95825-1898

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Delta Cross Channel (DCC) Fall-run Chinook salmon Monitoring Project (Project, MP-152, ENV-7.00)

Dear Ms. Leigh:

Thank you for your letter of May 20, 2016, requesting re-initiation of formal consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Delta Cross Channel (DCC) fall-run Chinook salmon Monitoring Project (Project, MP-152, ENV-7.00) with modifications of the project description during the second year of monitoring, and your letter of August 4, 2016, responding to our request for additional information.

This document transmits NMFS's biological opinion based on our review of the proposed DCC fall-run Chinook salmon Monitoring Project (MP-152, ENV-7.00) in Sacramento County for year two of the study (2015 and 2016) proposed by the U.S. Bureau of Reclamation (Reclamation), and its effects 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*), and threatened Southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*) and their designated critical habitats in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.).

Reclamation determined that the Project will not destroy or adversely affect designated critical habitats of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and sDPS of North American green sturgeon. Reclamation also has determined that the Project will not adversely affect Essential Fish Habitat for Pacific Salmon (*Oncorhynchus spp.*) in Amendment 18 of the Pacific Salmon Fishery Management Plan, and is not requesting Essential Fish Habitat consultation pursuant to section

305(b) of the Magnuson-Stevens Fishery Conservation and Management Act. Finally, although California sea lions (*Zalophus californianus*) and eastern Pacific harbor seals (*Phoca vitulina richardii*) may be present in the action area of the Project during its implementation, and are protected under the Marine Mammal Protection Act (1972), Reclamation has determined that the Project may affect, but is not likely to adversely affect marine mammals.

The enclosed biological opinion is based on information presented in the *Biological Assessment for Year 2016 Delta Cross Channel Fall-Run Chinook Salmon Monitoring Project,* prepared by Reclamation staff, additional information provided by Reclamation staff in response to NMFS's insufficiency letter and through email exchange with NMFS staff during the course of technical assistance and formal consultation for this Project, and an extensive literature review completed by NMFS staff. A complete administrative record of this consultation is on file at the NMFS Central Valley Office.

Based on the best available scientific and commercial information, the biological opinion concludes that the Delta Cross Channel (DCC) fall-run Chinook salmon Monitoring Project, including the temporary installation of two dual frequency identification sonar (Didson) units, seven acoustic telemetry receivers, and the deployment of three fyke traps in waters of the Delta near the DCC, is not likely to jeopardize the continued existence of the above listed species or adversely modify or destroy designated critical habitats.

NMFS has concluded that the Project, as described, will not jeopardize the continued existence of:

- Sacramento winter-run Chinook salmon
- Central Valley spring-run Chinook salmon
- California Central Valley steelhead
- sDPS of North American green sturgeon

NMFS has concluded that the Project will not result in the destruction or adverse modification of designated critical habitats for:

- California Central Valley steelhead
- sDPS of North American green sturgeon

Finally, NMFS has determined that the Project is not likely to adversely affect the designated critical habitats of Sacramento River winter-run Chinook salmon or Central Valley spring-run Chinook salmon.

NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take of listed salmonids and green sturgeon associated with the Project.

This section 7 consultation under the ESA does not provide incidental take under the Marine Mammal Protection Act. NMFS has determined that both California sea lions and eastern Pacific harbor seals may be present in the action area during the periods of net deployment. However, NMFS determined that the safeguards included in the project description, the incidental take statement, and the associated reasonable and prudent measures provide sufficient means to avoid any adverse interactions between marine mammals and the Project's fishing gear. NMFS does not anticipate that there will be any take of marine mammals during the implementation of this Project.

Also enclosed are Essential Fish Habitat (EFH) Conservation Recommendations for Pacific salmon as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*). This document concludes that operations of the fishing gears, monitoring equipment, and vessels associated with the Project will adversely affect EFH of Pacific salmon in the action area, and therefore adopts the ESA terms and conditions from the biological opinion as part of the Conservation Recommendations, as well as additional Conservation Recommendations in the EFH consultation section, which are based on the information contained in Appendix A of Amendment 18 to the Pacific Coast Salmon Plan to minimize or avoid effects of the Project on EFH.

Section 305(b)(4)(B) of the MSA requires Reclamation to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH Conservation Recommendations, including a description of measures adopted by Reclamation for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920(k)). 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 with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

We appreciate your continued cooperation in the conservation of listed species and their habitat, and look forward to working with you and your staff in the future. If you have any questions regarding this document, please contact Ms. Kristin McCleery in our California Central Valley Office, 650 Capitol Mall, Suite 5-100, Sacramento, CA 95814. Ms. McCleery may be reached by telephone at (916) 930-3718 or by e-mail at kristin.mccleery@noaa.gov.

Sincerely,

Maria Rea
for Barry A. Thom
Regional Administrator

Enclosure

Cc: Copy to File: 151422-WCR2015-SA00116

Mr. Harry Kahler, Natural Resource Specialist, U.S. Department of Interior, Bureau of Reclamation, Mid-Pacific Regional Office, 2800 Cottage Way, Sacramento, California 95825-1898

UNITED STATES DEPARTMENT OF COMMERCE
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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

Year 2016 Delta Cross Channel Fall-run Chinook Salmon Monitoring Project

NMFS Consultation Number: **WCR-2015-2534**

Action Agency: Bureau of Reclamation

Affected Species and NMFS' Determinations:

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

*Please refer to sections 2.4.1.1, 2.4.1.2, and 2.4.1.5 for the analysis of critical habitats that are not likely to be adversely affected.

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

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

Issued By: Maria Rea
for Barry A. Thom
Regional Administrator

Date: OCT 3 2016

Table of Contents

1.0 INTRODUCTION

The United States Bureau of Reclamation (Reclamation) proposed to fund and conduct a 2-year monitoring study between September 1 and November 13, 2015, and September 1 and November 12, 2016, that assesses the movement and behavior of adult fall-run Chinook salmon (*Oncorhynchus tshawytscha*) migrating upstream within the Mokelumne River system near the confluence with the Delta Cross Channel (DCC, Project). Due to 2015 results of capturing only one Chinook salmon, Reclamation has adjusted the fish sampling and monitoring methods for the 2016 monitoring project. Reclamation requested re-initiation of formal consultation in a letter to NOAA's National Marine Fisheries Service (NMFS) on May 20, 2016. The modified project involves the use of three metal fyke traps (instead of two trammel and two fyke nets), two dual-frequency identification sonar (Didson) camera units (instead of the less effective Biosonic DTX split-beam systems), and seven acoustic telemetry receivers to detect acoustic-tagged fish. In addition, the implementation for the 2016 study period was proposed for October 3 through December 1, 2016.

The DCC utilizes a pair of large radial gates located on the Sacramento River to regulate the flow of Sacramento River water into the Delta interior. When the gates are open, the channel conveys Sacramento River water into Snodgrass Slough and Dead Horse Cut and subsequently into the Mokelumne River system. This channel however, is still influenced by river and tidal flows and oscillations in flow velocity and stage are tidally driven on a daily basis. Tidal stage and river flow also determine the magnitude and timing of river flows that enter into the DCC from the Sacramento River (Horn and Blake 2004). This physical condition greatly influences the probability of juvenile salmonids (as well as other fish species) entering the DCC from the Sacramento River channel when the gates are in their open configuration. Furthermore, when the gates are open, the flow of Sacramento River water into the DCC waterway serves as an attractant flow to upstream migrating fish, particularly native anadromous fish such as Chinook salmon, sturgeon [both white sturgeon (*Acipenser transmontanus*) and green sturgeon (*A. medirostris*)], and steelhead (*O. mykiss*), as well as non-native fish such as striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) such that they move from the Mokelumne River system into the Sacramento River system through the manmade DCC waterway.

This artificial connection between the two river systems has led to concerns regarding the straying of fish from one basin to another. The California Department of Fish and Wildlife (CDFW) operates the Mokelumne River Fish Hatchery and produces both fall-run Chinook salmon and steelhead. Current practices by the hatchery release fall-run Chinook salmon smolts downstream from the hatchery in the waters of the western Delta near Antioch and Sherman Island. Fish are trucked to this downstream location and held briefly in net pens to acclimate to local environmental conditions prior to release. This practice was initiated to reduce the high losses of emigrating smolts through the interior of the Delta observed when smolts were released from the hatchery into the adjacent river (in-river release). Fisheries biologists believe that releasing of smolts in the western Delta has exacerbated straying rates due to the loss of olfactory imprinting on the fish's natal river chemistry as it migrates downstream. This tendency for returning adult hatchery fish to stray is also thought to be worsened by the open DCC gates during the period of upstream spawning migration. The relatively higher flows of the Sacramento River water through the open DCC compared to the lower flows in the Mokelumne

River serve as a false migratory cue or attractant to fish moving upriver. The result is poor returns to the Mokelumne River Fish Hatchery and significant problems with respect to the genetic integrity of different salmon populations from the straying of these fish to other watersheds (Reclamation 2015a).

To test strategies for reducing straying, the DCC gates were closed for two days in 2010 and 10 days in 2011 during the peak adult fall-run Chinook salmon up-migration in coordination with a pulse flow study from upstream reservoirs on the Mokelumne River timed to draw Chinook salmon into the river. The results showed a reduction in straying by 50 percent and 93 percent respectively (Reclamation 2015a). In 2012, Reclamation announced that it does not have the authority to close the DCC gates for fishery purposes if the Delta salinity standards are not being met. In response, the Golden Gate Salmon Association (GGSA) proposed a study to Reclamation to test the feasibility of installing a permanent, low voltage, graduated electric fish barrier (e-barrier) in Dead Horse Cut at the southeast corner of Dead Horse Island to discourage straying of Mokelumne River origin adult fall-run Chinook salmon into the DCC waterway. After discussions with staff from NMFS, biologists from the two agencies determined that prior to the authorization of the e-barrier study by Reclamation, that baseline data on the straying rates and movement behavior of adult fall-run Chinook salmon in the waterways surrounding Dead Horse Island and the DCC should be collected. This monitoring study is independent of the future e-barrier study and does not depend on this future study for its utility. Information collected during the currently-proposed monitoring study will be used for ongoing management efforts in the Mokelumne River system, including the potential e-barrier study in the future.

The proposed Project is designed to look at the distribution and migratory behavior of returning adult fish within the waterways surrounding the DCC and Dead Horse Island. It will use a combination of acoustic telemetry and Didson camera units to assess fish density, distribution, and movement behavior. Study fish (fall-run Chinook salmon) will be collected by passive fishing gears (fyke traps) deployed in the waters of the north and south forks of the Mokelumne River downstream of Dead Horse Island, and in Dead Horse Cut. These fish will be tagged with acoustic tags and tracked through a regional telemetry array deployed in the waterways surrounding the DCC location. Bycatch of the passive fishing gear will be used to cross-validate the return signals of the hydroacoustic arrays to determine species diversity and size ranges of fish present in the vicinity during the study period. Sampling will only be conducted while the DCC gates are open, since there would be no scientific value to monitoring when they are closed (Reclamation 2016a).

1.1 Background

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 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

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

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

1.2 Consultation History

On February 4, 2014, Reclamation invited NMFS to be part of a multi-agency technical advisory team to provide guidance and technical expertise on fish deterrent studies proposed for the DCC and Mokelumne River waterways.

From March 4, 2014, to February 2015, NMFS provide Reclamation with technical assistance regarding the development of the Project. This included attending multiple meetings, exchanges of emails, and phone calls between agency biologists. Topics addressed including multiple permitting issues, piecemealing of the project into discrete components, impacts to marine mammals (seals and sea lions), and conservation measures to minimize and avoid impacts.

On March 25, 2015, NMFS received a request for formal consultation pursuant to section 7 of the ESA and for consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) regarding the effects of the proposed project on EFH identified in Amendment 18 to the Pacific Coast Salmon Fishery Management Plan (FMP) (Reclamation 2015a). A biological assessment for the proposed study was included with this request for initiation. NMFS responded on April 24, 2015, that it had received sufficient information to initiate formal consultation under section 7 the ESA and that a biological opinion will be completed on or before August 7, 2015.

On August 6, 2015, Reclamation requested suspension of formal consultation for the DCC Fall-run Chinook salmon Monitoring Project so it can revise the project description.

On August 13, 2015, NMFS received Reclamation's August 12, 2015, letter requesting the modification of the DCC Fall-run Chinook salmon Monitoring Study, adding an additional year of study to the proposed Project (Reclamation 2015b).

On September 15, 2015, NMFS issued to Reclamation a completed Biological Opinion for the DCC Fall-run Chinook salmon Monitoring Project (Project, MP-400, ENV-7.00).

On May 20, 2016, NMFS received Reclamation's request for re-initiation of formal consultation with project modifications which include the use of fyke traps instead of fyke traps and trammel nets. The Biological Assessment for 2016 monitoring was also received.

On June 24, 2016, NMFS submitted an insufficiency letter to Reclamation. Reclamation responded on August 4, 2016.

On September 27, 2016, NMFS requested additional information on several questions. Reclamation responded via email on the same day.

On September 29, 2016, NMFS inquired about coordinates of new camera locations. Reclamation responded via phone and email.

1.3 Proposed Action

1.3.1 Overview

"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). Reclamation is proposing to fund and conduct the second season of the monitoring Project from early October to December 1, 2016. As the funding and implementing Federal agency, Reclamation has determined that it is the lead Federal agency in this section 7 consultation with NMFS under the ESA, although permits will be required from the United States Army Corps of Engineers (Corps) to place equipment in the waters of the United States. The purpose of the Project is to assess the movements and migratory behavior of adult fall-run Chinook salmon in the waterways surrounding Dead Horse Island during their upstream spawning migration in the Mokelumne River system in the eastern Sacramento-San Joaquin Delta (Figure 19). Adult fall-run Chinook salmon will be captured by passive fishing gear (fyke traps) in the Mokelumne River system adjacent to Dead Horse Island. Up to 100 adult fall-run Chinook salmon will be captured for the 2016 study year. Each study fish will have an acoustic tag inserted into their esophagus and will be marked with a visible external tag, and released unharmed into the waters in which they were captured to continue their upstream migration. Fish movements within the waterways surrounding Dead Horse Island and the waters of the Sacramento River immediately adjacent to the junction with the upstream side of the DCC will be detected by acoustic telemetry receivers and Didson camera equipment located in these waterways. Information gathered during this 2-year Project (2015-2016) will be used to inform future management strategies to enhance the return of fall-run Chinook salmon to the Mokelumne River Hatchery.

1.3.2 Agency Participation

The proposed Project will require additional permits from the Corps in compliance with sections 401 and 404 of the Clean Water Act, and section 10 of the Rivers and Harbors Act. In addition, the United States Fish and Wildlife Service (USFWS) and the California Department of Fish and Wildlife (CDFW) are involved regarding impacts to species under their respective jurisdictions.

1.3.3 Project Components

The Project involves monitoring upstream migrating adult fall-run Chinook salmon movements in the channels downstream of the DCC during the study seasons (2015 and 2016), which entails the temporary placement of two Didson camera units, seven acoustic telemetry receivers, and deploying three metal fyke traps to catch target fish for tagging and comparison of sampled bycatch to the hydroacoustic dataset for species diversity and size distribution. The collected dataset will serve as baseline data for comparisons to adult fall-run movements before and after implementation of management options in 2017, which may include an e-barrier option. Final decisions on which management option may be implemented have not been confirmed at this time. Figure 20 shows the locations of the proposed acoustic receivers, the Didson camera units, and the fyke traps in the project area for the 2016 study season.

1.3.3.1 Dual-Frequency Identification Sonar (Didson) Camera Systems

To monitor passage of fish > 440 mm (15.75 inches) in length, including adult Chinook salmon, Reclamation is proposing to employ a Didson camera system in Snodgrass Slough and in Dead Horse Cut. Approximate Didson station/support equipment waypoints (lat. and long. coordinates) are as follows:

D1: 38°13'31.75"N, -121°30'26.05"W; 38°13'32.27"N, -121°30'29.98"W (Snodgrass Slough)
D2: 38°13'44.3"N, -121°29'40.5"W; 38°13'44.6"N -121°29'37.4"W (Dead Horse Cut)

The dual-frequency acoustic systems (Units D1 and D2) will monitor the channels on both the east and west sides of Dead Horse Island (Figure 19). Each system consists of two primary components, including a surface unit, with support equipment of control hardware and power supply (Figure 20), and a submerged transducer placed in the river channel. Each system has two transducers with attached rotators, one on each side of the channel facing across at each other. Each system has an array and acoustic lens contained in an underwater housing, and provides near-video quality images, and attaches to a rotator assembly (Moursund *et al.* 2003). The active sonar head and rotator assemblies will be mounted on aluminum tripods [1.0 meter (m) x 1.0 m x 1.0 m, approximately 3.3 feet (ft) x 3.3 ft x 3.3 ft] that rest on the channel bottom substrate (Figure 22), and uses the weight of the tripod to hold it in place. Tripods are placed at a depth to ensure they remain completely submerged during the lowest tide predicted in the deployment locations and, therefore, will not be affected by changes in the river stage. Depending on the channel's shoreline slope and cross sectional geometry, tripods may be tied off to the shore to prevent movement from river currents and boat wakes. Ties typically consist of a cable or rope tied to the tripod, and around either a rock or small tree on the embankment. If deemed necessary, additional weight will be added to the base of the tripod to hold it in position. From the sonar head, the power data cable will run up to the surface units located in job boxes at a location on the shore in close proximity to the transducers (Reclamation 2015a).

The primary component of a hydroacoustic data collection system is the scientific echo sounder and transducer. When triggered, the echo sounder emits a short electrical pulse of known frequency, duration, and transmitted power. The transducer then converts the electrical pulse into mechanical energy (*i.e.*, a sound pulse with the same characteristics as the electrical pulse). When the sound waves encounter fish, echoes are reflected back to the transducer from the fish. The transducer then converts the received sound energy back into electrical energy and the electrical signal is sent back to the receiver portion of the echo sounder. The echo signals, now defined by an electrical signal from the conversion of sound waves received by the transducer into electrical current, are relayed to the computer-based echo processor. The returning echoes from fish have characteristics that allow them to be tracked across successive echo returns. The frequencies of the sound emissions for the split beam sonar are above the hearing thresholds for fish, and are not expected to be detectable by fish within the ensonified area of the water column.

The hydroacoustic study will be conducted for a total monitoring period of 7 weeks during the 2016 study season, which will occur during a 7-week period between October 3 and December 1, depending on when fall-run Chinook salmon are first observed by East Bay Municipal Utility District at Woodbridge Irrigation District Dam (Reclamation 2016a). The hydroacoustic system will collect data intermittently throughout this period; however, the equipment will remain deployed throughout the 2-month 2016 study period, even during periods of non-operation. A mesh fish excluder will be placed over the fyke trap openings when traps are not in use (Reclamation 2016a). The transducers and cables will be removed from the river no later than December 1 for the 2016 study season.

Data acquired using the hydroacoustic methods may not easily permit determination of different species of fish. Though the abundance of larger species of fish that could potentially be confused (based on target strength) with adult salmon, including native steelhead, large native cyprinids (*i.e.*, Sacramento splittail, Sacramento pikeminnow), and catostomids (Sacramento sucker), and non-native cyprinids (*i.e.*, common carp), are reportedly relatively low in the lower Mokelumne River in comparison to adult salmon during the fall-run migration, they are present. Therefore, an estimation of the proportion of different species of large fish traversing the barrier will be necessary for data post-processing. This will be accomplished through examination of the bycatch in the passive fishing gears explained below.

1.3.3.2 Acoustic Telemetry Receivers

To monitor fish movements of individual-tagged adult fall-run Chinook salmon from lower reaches of the Mokelumne River into and through the study area (Figure 20), acoustic receivers (~308 mm long x 73 mm diameter) would be deployed in the following locations throughout the study area.

A1: 38°13'24.48"N, 121°30'25.26"W
A2: 38°13'36.80"N, 121°30'3.76"W
A3: 38°13'32.15"N, 121°29'28.54"W
A4: 38°13'57.63"N, 121°29'26.16"W
A5: 38°13'45.65"N, 121°30'36.47"W
A6: 38°14'25.05"N, 121°29'46.87"W
A7: 38°14'44.98"N, 121°30'40.33"W

The small receivers (Figure 23) will be secured, using heavy duty zip ties, to a rope, with one end of the rope attached to a small {approximately 13.6 kilogram (kg) [30 pounds (lbs)]} anchor and the other end attached to a floatable buoy. The anchor will not be keyed into the streambed. To minimize disturbances from the public and to reduce impacts to boaters in the area, the buoys will be secured in a fashion to allow them to float approximately 1 m (3.3 ft) below the surface at the lowest predicted water level in the study area. A quarter-sized temperature sensor will also be attached to acoustic receivers anchored in Snodgrass Slough at the Mokelumne River confluence, Dead Horse Cut at the Mokelumne River confluence, and in the mainstem Mokelumne River.

The acoustic tag study was initially proposed to be conducted over a 7-week period between September 1 and November 30, 2016. However, due to the late timing, the 2016 study period will occur over a 7-week period between October 1 and November 30 (Kahler 2016). Following the data collection period, the hydrophones and cables, will be removed from the river by December 1, 2016.

1.3.3.3 Fish Sampling

A total of up to 100 adult fall-run Chinook salmon will be collected, measured, and tagged within the study area. Reclamation proposes that up to 50 fish each will be tagged in the North and South Forks of the Mokelumne River. Fish will be collected using fyke traps, a passive type of fishing gear, which has a reduced risk of injuring or stressing captured fish compared to fyke nets, which can entangle fish.

Fish will be captured to provide information for two purposes in this study. The two main purposes of the fish sampling are to: (1) capture adult fall-run Chinook salmon for tagging with acoustic transmitters; and (2) identify, measure, and enumerate all species of fish caught as bycatch in the passive fishing gear to provide a cross reference to identify the diversity of targets detected by the hydroacoustic equipment deployed in Snodgrass Slough, Dead Horse Cut, mainstem Sacramento River, and several locations in the Mokelumne River.

Captured adult fall-run Chinook salmon at the two Mokelumne River locations will be implanted with an acoustic transmitter [~ 9 millimeter (mm) width, ~29 mm length, ~4.7 grams (g) weight in air] inserted into the esophageal cavity, and outfitted with an external Peterson Disc tag. Acoustic transmitters inserted into the esophageal cavity of adult salmon will be programmed to omit an acoustic “ping” every minute which will allow for a battery life of approximately 100 days. When an active transmitter is in close proximity to a stationary acoustic receiver [~ 400 m (1,312 ft) line of sight distance], a unique transmitter ID, date, and time will be recorded. The receiver data will be periodically downloaded and post-processed to determine tag detections, direction of travel, and rate of travel through the receiver array. All fish captured at the Dead Horse Cut location will be identified to species, measured for length, and immediately returned to the water in close proximity to the point of capture. This activity will quantify species presence and ultimately apply percentage of each species and size ranges to the hydroacoustic data set to determine the proportion of salmon captured in the study area. Listed fish species will be quickly returned to the river in a healthy condition after lengths are measured. If any of the captured fish appear to be stressed or disoriented, they will be maintained in small (~100 cm x 100 cm x 150 cm) net pens or transport containers for recovery, but will be released in the same channel of capture shortly (< 2h) following tagging efforts.

For the 2016 study year, fyke traps will be used instead of fyke nets and trammel nets, which were used during the 2015 study year (Figure 1). Fyke traps are commonly used as a fish capture technique for research as they are designed to have a lower chance of causing injuries to fish, and induce less stress on captured fish than do gill nets (Hopkins and Cech 1992). The fyke trap is designed as a passive fishing method to catch fish migrating up the river system. It consists of two compartments, each about 6 to 8 feet long. The total length is approximately 20 feet long and is about 10 feet in diameter (Reclamation 2016a). It is constructed of coated chain link fence [2-inch (5.1 cm) mesh]. Three fyke traps would be fished at different locations, on the North Fork Mokelumne River, on the South Mokelumne River, and upstream of the hydroacoustic stations on Dead Horse Cut (Figure 20). The traps will be secured in place with t-posts in the embankment slope. They will be submerged at each site and are retrieved using handheld roped and electric truck-mounted winches. While the trap is partially submerged to provide water for trapped fish, swinging doors allow entrance to remove fish using large dip-nets. The traps will be fitted with large mammal excluders fitted on the openings. Traps will be checked at a minimum once daily. When they cannot be checked daily, they will be removed and stored on land.

Target fish (*i.e.*, adult fall-run Chinook salmon) captured using this method in the North and South Forks of Mokelumne River would be measured for length, have an acoustic transmitter inserted into their esophageal cavity, tagged with a Peterson Disc tag, and immediately returned to the river in close proximity to their point of capture. Only healthy, active target fish will be tagged. All other fish will be measured for length and quickly returned to the river. If captured fish show signs of stress, they will be maintained in small (~100 cm x 100 cm x 150 cm) net pens or transport containers flushed with clean oxygenated river water for recovery, and released in the same channel of capture within two hours of capture. This activity, as well as fish captured in the Dead Horse Cut fyke trap, will quantify species presence and ultimately apply percentage of each species to the hydroacoustic data set to determine the proportion of salmon sampled.

Water quality will be continuously monitored during handling to maintain adequate water temperatures. Handling and tagging of fall-run Chinook salmon will only occur when water temperature is less than or equal to a daily average of 22.5 degrees Celsius (°C, 72.5°F). When water temperatures reach or exceed 22.5°C, traps will be closed and operations will cease until temperatures decrease. Water temperature data will be retrieved from a nearby USGS and CDWR station, as well as from individual temperature loggers attached to each trap.

Reclamation reports that the maximum water temperature observed in the South Fork of the Mokelumne River in September 2014, was 25°C (77°F), which gradually decreased to approximately 14°C (57.2°F) by the first week of November 2014. The maximum water temperature in the North Fork of the Mokelumne River in September 2014, was 24°C (75.2°F), which gradually decreased to approximately 15°C (59.0°F) by the first week of November 2014. Reclamation anticipates similar water temperature conditions for the fall of 2015 and 2016 which informs future deployment options for these study seasons (Reclamation 2015a, b).

Figure 1. Example Fyke Trap (Reclamation 2016a).

Floatable warning buoys will be installed at each monitoring device location to inform boaters and other recreationists of the in-water devices. These buoys will be held in place by a cable connected to a concrete weight anchor that will not require digging into the streambed. The anchor will, however, disturb a small area of benthic substrate for the duration of the study.

1.3.4 Best Management Practices/ Conservation Measures

Reclamation proposes the following best management practices/ conservation measures to minimize and avoid adverse effects to listed salmonids, green sturgeon, and marine mammals potentially present in the study area. Implementation of the best management practices will serve a dual purpose as conservation measures to protect captured fish, including listed species, and to report the capture or loss of any listed species or marine mammals to the appropriate agencies.

- Fish sampling will be performed by qualified fish biologists.
- When fyke traps are not being fished, a mesh fish excluder will be placed over the opening. If necessary, the fyke traps may be completely removed from the water.
- Fish biologists will inspect the fishing gear daily from land or by boat if needed.
- Marker buoys will be deployed on the upstream and downstream sides of the traps to warn boaters of presence of the traps. If necessary, fish biologists will either move the traps to a different area or remove the traps to allow safe boat passage.
- If listed fish are incidentally captured, fish biologists will minimize their time in the traps and handling. Fish will be gently removed from the trap, held in the recovery net pens flushed with clean oxygenated river water if necessary, and immediately released at the trapping location. Recovery net pens will be sized up to 7 feet long for adult sturgeon.
- Target fish caught for tagging will be measured, tagged, and released back to their point of capture within 10 minutes of capture. Captured non-target fish will be identified to

species and immediately released. After November 15, 2016, any fish that are not gravid will be assumed to be winter-run Chinook salmon, and will be released. If a total of 50 fish have not been tagged, tagging of only clipped fish will occur (Reclamation 2016b).

- Incidental catch of listed fish and marine mammals will be reported to NMFS and USFWS.
- Dead or injured listed fish and marine mammals will be reported to NMFS and USFWS immediately.

1.3.5 Interrelated and Interdependent Actions

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

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).

NMFS has defined the action area as the waterways impacted by the monitoring studies, including the deployment of the passive fishing gears (fyke traps) and the hydroacoustic and telemetry arrays within the channels surrounding Dead Horse Island, the North and South Forks of the Mokelumne River, the DCC, and the junction of the DCC with the Sacramento River. NMFS will use a buffer zone of 400 meters (~1300 feet) downstream of the location of fyke trap on the North Fork of the Mokelumne River, 400 meters (~1300 feet) downstream of fyke trap on the South Fork of the Mokelumne River, a point 200 meters (~650 feet) upstream of acoustic receiver "A4" in the Mokelumne River mainstem (A4 on Figure 20), a line drawn directly across channel of Snodgrass Slough from the eastern end of the DCC's north shore to the opposite bank of Snodgrass Slough, and a reach of the Sacramento River adjacent to the western end of the DCC, stretching 200 meters upstream and downstream of the DCC junction. The action area is depicted in Figure 24 and includes the waterways between the endpoints described above. Sacramento River winter-run Chinook salmon, Central Valley (CV) spring-run Chinook salmon, California Central Valley steelhead (CCV steelhead), and the sDPS of North American green sturgeon) have the potential to occur in the action area during the proposed 2016 study period. Designated critical habitats occur in the action area for winter-run (Sacramento River), CV spring-run (Sacramento River and DCC), CCV steelhead (Delta waters) and the sDPS of North American green sturgeon (Delta waters).

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

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

2.1 Analytical Approach

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

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

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

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

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and

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

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 physical and biological features that help to form that conservation value.

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

- First listed as threatened (August 4,1989, 54 Federal Register (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)
- Designated critical habitat (June 16, 1993, 58 FR 33212)

The Federally listed ESU of Sacramento River winter-run Chinook salmon and designated critical habitat occurs in the action area and may be affected by the proposed Project.

2.2.1.1 Species Listing and Critical Habitat History

The Sacramento River winter-run Chinook salmon (winter-run, *O. 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).

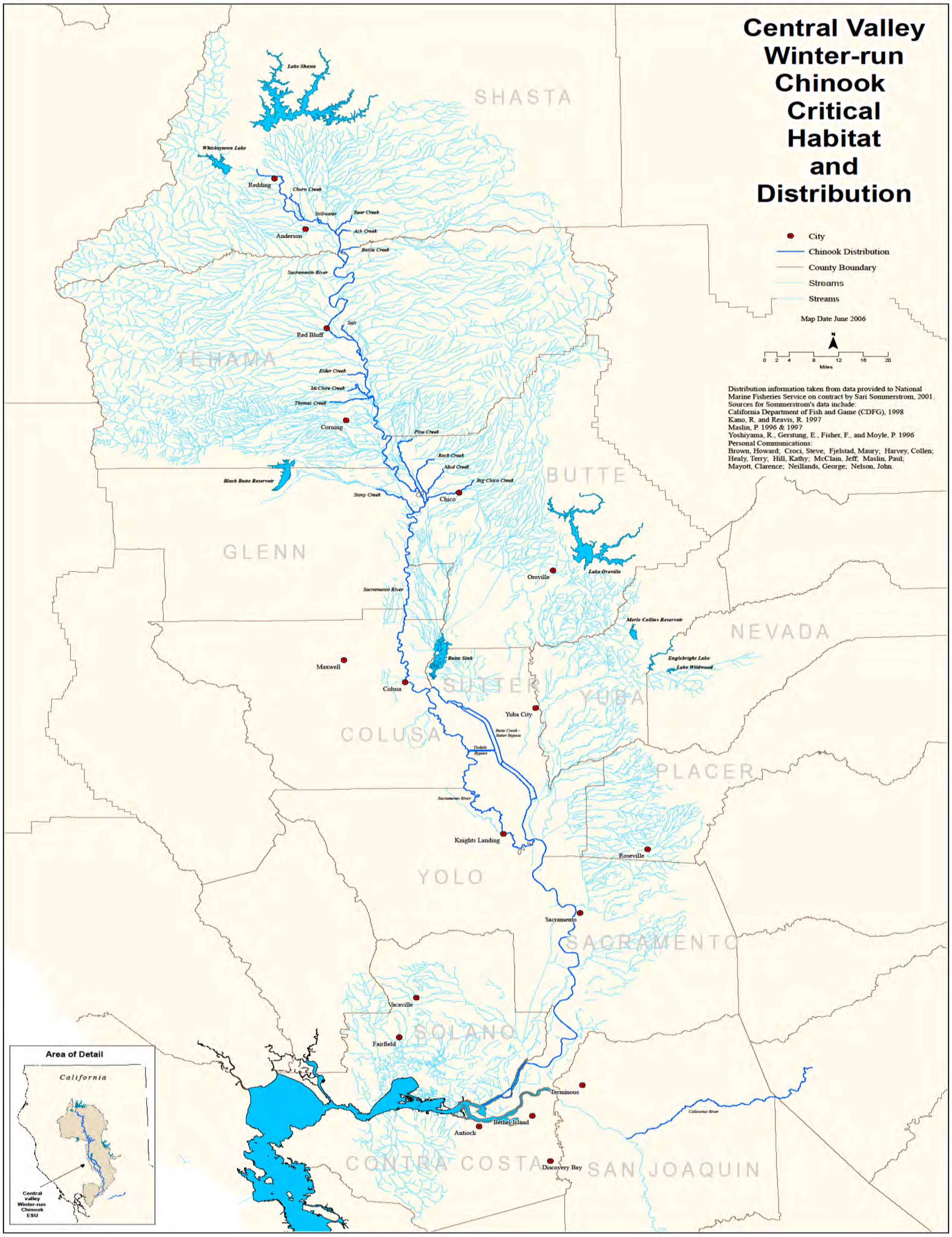
On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of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

NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at river mile (RM) 302 [river kilometer (RKM) 486] to Chipps Island, RM 0 (RKM 0), at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. In the Sacramento River, critical habitat includes the river water, river bottom, and the adjacent riparian zone.

2.2.1.2 Critical Habitat: Essential Features for Sacramento River Winter-run Chinook Salmon

Critical habitat for winter-run is defined as specific areas (listed below) that contain the physical and biological features considered essential to the conservation of the species (Figure 2). This designation includes the river water, river bottom (including those areas and associated gravel used by winter-run as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing (June 16, 1993, 58 FR 33212). NMFS limits "adjacent riparian zones" to only those areas above a stream bank that provide cover and shade to the near shore aquatic areas. Although the bypasses (*e.g.,* Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run may use tributaries of the Sacramento River for non-natal rearing (Maslin *et al.* 1997, Pacific States Marine Fisheries Commission (PSMFC) 2014). Critical habitat also includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile outmigration or adult spawning migration.



Distribution information taken from data provided to National Marine Fisheries Service on contract by Sari Sommerstrom, 2001.
Sources for Sommerstrom's data include:
California Department of Fish and Game (CDFG), 1998
Kano, R. and Reavis, R. 1997
Maslin, P. 1996 & 1997
Yoshiyama, R., Gerstung, E., Fisher, F., and Moyle, P. 1996
Personal Communications:
Brown, Howard; Croci, Steve; Fjelstad, Maury; Harvey, Collen; Healy, Terry; Hill, Kathy; McClain, Jeff; Maslin, Paul; Mayott, Clarence; Neillands, George; Nelson, John.

Figure 2. Winter-run Chinook salmon distribution and critical habitat in the Central Valley.

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

1. Adult Migration Corridors

Adult migration corridors are defined as providing "access from the Pacific Ocean to appropriate spawning areas, providing satisfactory water quality, water quantity, water temperature, water velocity, cover, shelter, and safe passage conditions in order for adults to reach spawning areas." Adult winter-run generally migrate to spawning areas during the winter and spring. At that time of year, the migration route is accessible to the appropriate spawning grounds on the upper 96.6 km (60 miles) of the Sacramento River, however much of this migratory habitat is degraded and they must pass through a fish ladder at the Anderson-Cottonwood Irrigation Dam (ACID). In addition, the many flood bypasses are known to strand adults in agricultural drains due to inadequate screening (Vincik and Johnson 2013). Since the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

2. Spawning Habitat

Spawning habitat is defined as "the availability of clean gravel for spawning substrate." Suitable spawning habitat for winter-run exists in the upper 96.6 km (60 miles) of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD). However, the majority of spawning habitat currently being used occurs in the first 16.1 km (10 miles) below Keswick Dam. The available spawning habit is completely outside the historical range utilized by winter-run upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, Reclamation annually injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the upper Sacramento River reach continues to support a small naturally-spawning winter-run Chinook salmon population. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

3. Adequate River Flows

Adequate River flows are defined as providing "adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles." An April 5, 1960, Memorandum of Agreement between Reclamation and the CDFW (formerly California Department of Fish and Game [CDFG]) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in State Water Resource Control Board (SWRCB) Water Rights Order (WRO) 90-05 for the protection of Chinook salmon. This order includes a minimum flow release of 3,250 cubic feet per second (cfs) (92.03 cubic meters per second [m^3s^{-1}]) from Keswick Dam downstream to RBDD from September through February during all water year types, except critically dry.

4. Water Temperatures

Water temperatures are defined as “water temperatures at 5.8–14.1°C (42.5–57.5°F) for successful spawning, egg incubation, and fry development.” Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of winter-run migration, spawning, egg incubation, fry development, and emergence. This pattern, the opposite of the pre-dam hydrograph, benefits winter-run by providing cold water for miles downstream of the Shasta/ Keswick dams during the hottest part of the year. The extent to which winter-run habitat needs are met depends on Reclamation’s other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir end of September storage levels required in the NMFS 2009 biological opinion on the long-term operations of the Central Valley Project and State Water Project (CVP/SWP, NMFS 2009). WRO 90-05 and 91-1 require Reclamation to operate Shasta, Keswick, and Spring Creek Powerhouse to meet a daily average water temperature of 13.3°C (56°F) at RBDD. They also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. Based on these requirements, Reclamation models monthly forecasts and determines how far downstream 13.3°C (56°F) can be maintained throughout the winter-run spawning, egg incubation, and fry development stages.

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

5. Habitat and Adequate Prey Free of Contaminants

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

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

6. Riparian and Floodplain Habitat

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

7. Juvenile Emigration Corridors

Juvenile emigration corridors are defined as providing "access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean." Freshwater emigration corridors should be free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. Migratory corridors are downstream of the Keswick Dam spawning areas and include the mainstem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River and in the Delta. Predators such as striped bass and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon.

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

8. Summary of the Essential Features of Winter-run Chinook Salmon Critical Habitat

Critical habitat for winter-run is composed of physical and biological features that are essential for the conservation of winter-run, including upstream and downstream access, and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these physical and biological features are degraded, and provide limited high quality habitat. Additional features that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows in the Delta, and the lack of floodplain habitat.

In addition, water operations that limit the extent of cold water below Shasta Dam have reduced the available spawning habitat (based on water temperature). Although the habitat for winter-run has been highly degraded, the importance of the reduced spawning habitat, migratory corridors, and rearing habitat that remains is of high conservation value.

2.2.1.3 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 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 (see Table 2 below; (Yoshiyama *et al*. 1998, Moyle 2002).

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, 80.5 km) 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, Snider *et al.* 2001). The majority of winter-run adults return after three years.

Table 2. 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. <u>Egg and Fry Emergence</u>

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 in mean daily water temperatures above 57.5°F (14.2°C); (Seymour 1956, Boles 1988, USFWS 1998, EPA 2003, Richter and Kolmes 2005, 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 (RKM 389.5, RM 242) may begin as early as mid-July, but typically peaks at the end of September (Table 2), 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), 91.7 RKM (RM 57) (USFWS 2001). 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 400 m^3s^{-1} (~14,000 cfs) at Knights Landing, 144.8 RKM (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 (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 from 5 to 10 months of age, by the time they depart the Delta (Fisher 1994, Myers *et al*. 1998).

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 consist of anchovy, rockfish, herring, and other invertebrates (in order of preference, (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 stay near the California coast and distribute from Point Arena southward to Monterey Bay. 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

Chinook salmon reach age 4. Once they reach age 3, they are large enough to become vulnerable to commercial and sport fisheries.

2.2.1.4 Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the winter-run Chinook salmon 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, 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 2011a). In recent years, since carcass surveys began in 2001 (Figure 3), 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 3). 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 2011a). In 2014, the population was 3,015 adults, slightly above the 2007–2012 average, but below the high (17,296) for the last ten 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). Therefore, hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year.

2014 was the third year of an ongoing drought which increased water temperatures in the upper Sacramento River. This caused significantly higher mortality (95-97 percent) in the upper spawning area. Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled to offset the impact of the drought. In 2014, hatchery production represented 50-60 percent of the total in-river juvenile production. Drought conditions are likely to persist into 2015 and hatchery production will again be increased.

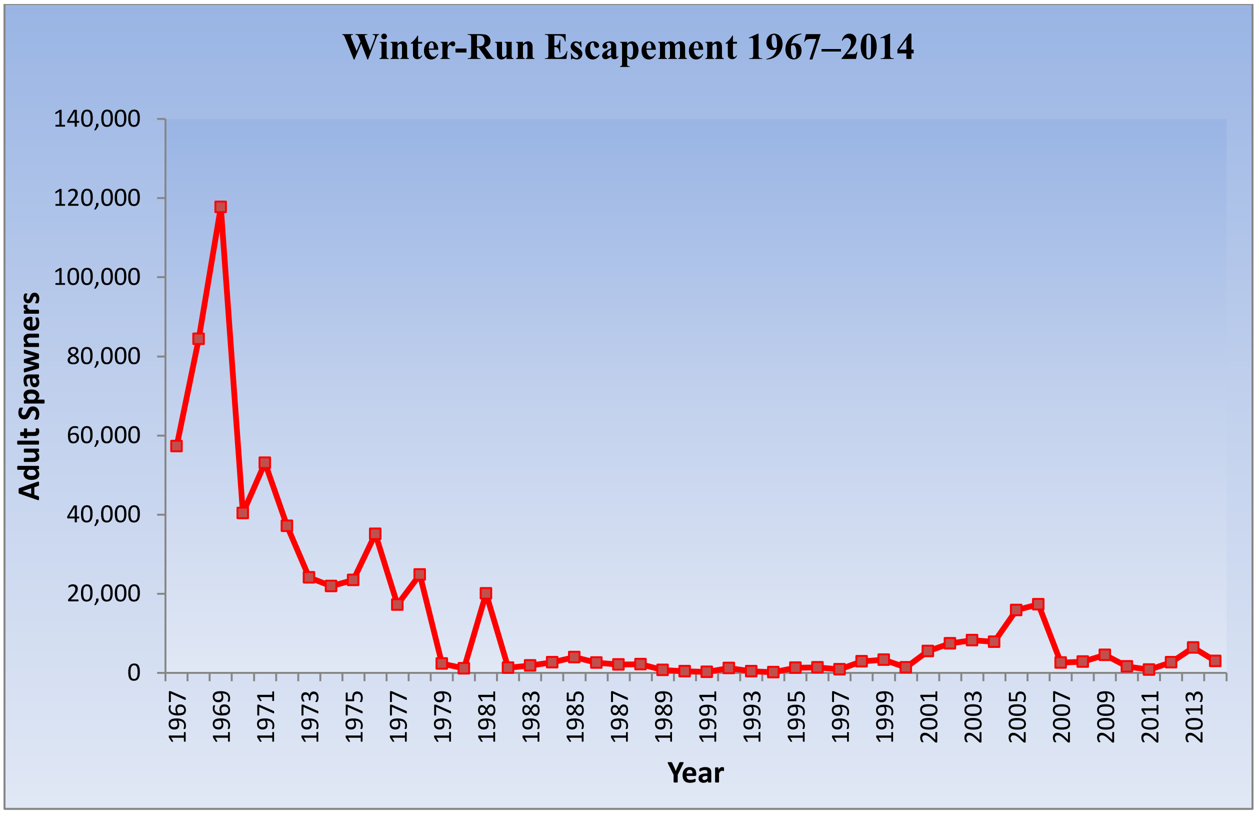


Figure 3. Winter-run Chinook salmon escapement numbers 1970-2014, includes hatchery broodstock and tributaries, but excludes sport catch. RBDD ladder counts used pre-2000, carcass surveys post 2001 (CDFG 2012).

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 4) with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggested a reduction in productivity (Figure 4), and indicated that the winter-run population was not replacing itself. In 2013, and 2014, winter-run experienced a positive CRR, possibly due to favorable in-river conditions in 2011, and 2012 (wet years), which increased juvenile survival to the ocean.

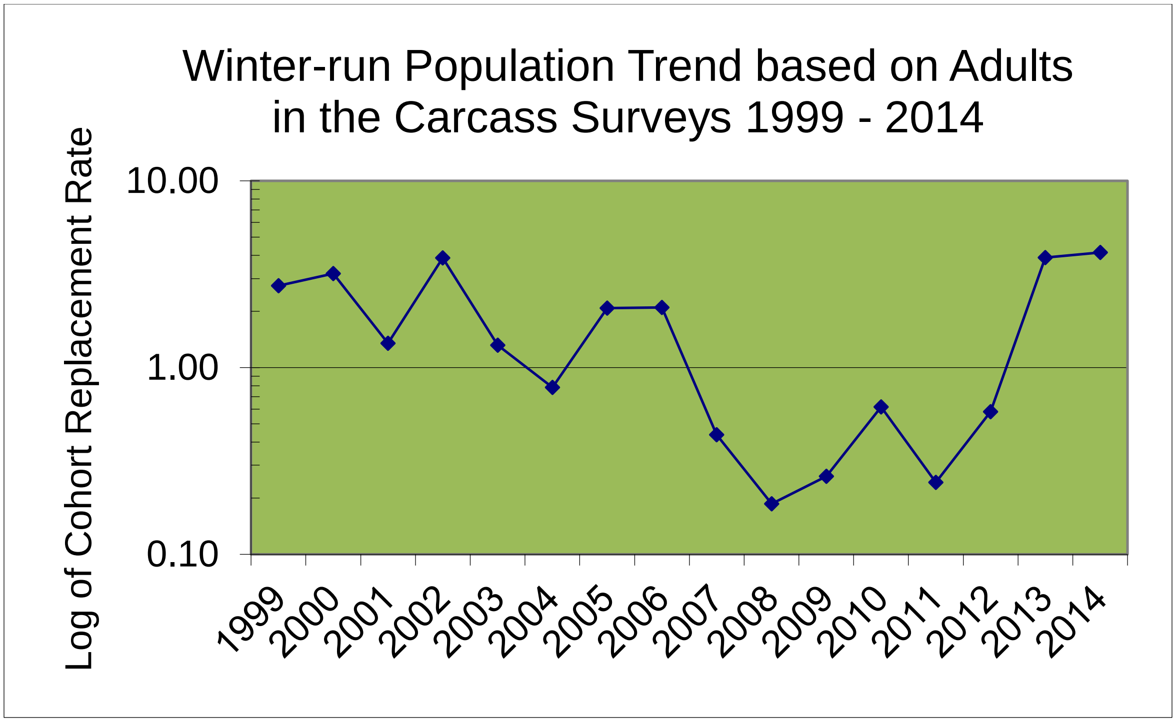


Figure 4. Winter-run population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1999–2014.

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 (Good *et al*. 2005). 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 2011a). 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 (Table 3). Due to uncertainties in the various JPE factors, it was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences model), and again in 2013, and 2014 with a change in survival based on acoustic tag data (NMFS 2015a). However, juvenile winter-run productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

Table 3. Winter-run adult and juvenile population estimates based on RBDD counts (1986–2001) and carcass counts (2001–2014), with corresponding 3-year-cohort replacement rates.

Return Year	**Adult Population Estimate**[a]	**Cohort Replacement Rate**[b]	**Juvenile Production Estimate (JPE)**[c]
1986	2596		
1987	2185		
1988	2878		
1989	696	0.27	
1990	430	0.20	
1991	211	0.07	
1992	1240	1.78	40,100
1993	387	0.90	273,100
1994	186	0.88	90,500
1995	1297	1.05	74,500
1996	1337	3.45	338,107
1997	880	4.73	165,069
1998	2992	2.31	138,316
1999	3288	2.46	454,792
2000	1352	1.54	289,724
2001	8224	2.75	370,221
2002	7441	2.26	1,864,802
2003	8218	6.08	2,136,747
2004	7869	0.96	1,896,649
2005	15839	2.13	881,719
2006	17296	2.10	3,556,995
2007	2542	0.32	3,890,534
2008	2830	0.18	1,100,067
2009	4537	0.26	1,152,043
2010	1,596	0.63	1,144,860
2011	827	0.29	332,012
2012	2,674	0.59	162,051
2013	6,075	3.88	1,196,387
2014	3,015	4.13	124,521
median	3,709	0.95	874,931

[a] Population estimates include hatchery returns based on RBDD ladder counts until 2001, after which the methodology changed to carcass surveys (CDFG 2012).

[b] Assumes all adults return after three years. CRR is calculated using the adult spawning population, divided by the spawning population three years prior. Two year old returns were not used.

[c] Includes survival estimates from spawning to Delta (*i.e.*, Sacramento at I St Bridge) entrance, but does not include through-Delta survival.

3. Spatial Structure

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

The 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 (CNFH) weir]. The Battle Creek Salmon and Steelhead Restoration Project 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 (National Marine Fisheries Service 2011a). 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 Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014). Additionally, NMFS (2009) included a requirement for a pilot fish passage program above Shasta Dam.

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 current winter-run population is the result of the introgression of several stocks (*e.g.,* spring-run and fall-run Chinook) 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 recovered in the Sacramento River has only been above 15 percent in two years, 2005 and 2012 (Figure 5).

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 5). However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley *et al*. (2007).

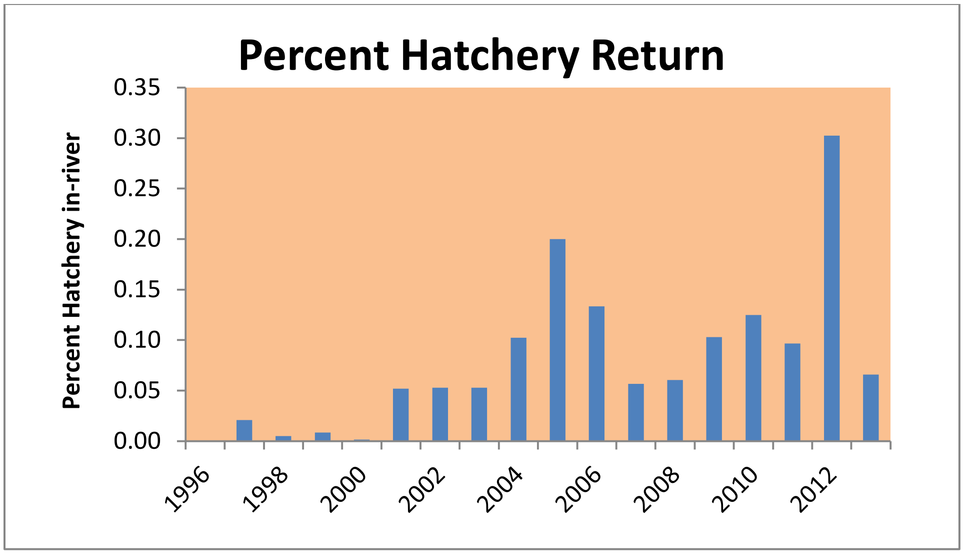


Figure 5. Percentage of hatchery-origin winter-run Chinook salmon naturally spawning in the Sacramento River (1996–2013). Source: CDFW carcass surveys, 2013.

5. <u>Summary of ESU Viability</u>

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 to the criteria in Lindley *et al*. (2007). Recent trends in those criteria are: (1) continued low abundance (Figure 3); (2) a negative growth rate over 6 years (2006–2012), which is two complete generations (Figure 4); (3) a significant rate of decline since 2006; and (4) increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change). The most recent 5-year status review (NMFS 2011a) on winter-run concluded that the ESU had increased to a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the winter-run ESU has increased from moderate risk to high risk of extinction since 2005 (last review), and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (NMFS 2011a).

2.2.2 CV spring-run Chinook salmon ESU

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

The Federally listed ESU of CV spring-run Chinook salmon and designated critical habitat occurs in the action area and may be affected by the proposed Project.

2.2.2.1 Species Listing and Critical Habitat History

CV spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent CV spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

In August 2011, NMFS completed an updated status review of five Pacific Salmon ESUs, including CV spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (76 FR 50447). The 2011 Status Review (NMFS 2011b) 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.

2.2.2.2 Critical Habitat and Physical and Biological Features (PBFs) for CV Spring-run Chinook Salmon

Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Following are the PBFs for CV spring-run Chinook salmon.

1. Spawning Habitat

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

2. Freshwater Rearing Habitat

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

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstem of the Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (i.e., hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. The stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik and Johnson 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PBF. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

4. Estuarine Areas

Estuarine areas, such as the San Francisco Bay and the downstream portions of the Sacramento-San Joaquin Delta, 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 large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging.

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

2.2.2.3 Life History

1. Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run Chinook salmon 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 Chinook salmon 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 4 in text). Typically, spring-run Chinook salmon 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 3ºC (38ºF) to 13ºC (56ºF) (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 18ºC (65ºF) for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 21ºC (70ºF), and that fish can become stressed as temperatures approach 21ºC (70ºF). Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 15.6 ºC (60ºF); although salmon can tolerate temperatures up to 18 ºC (65ºF) before they experience an increased susceptibility to disease (Williams 2006).

2. Adult Spawning

Spring-run Chinook salmon 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 Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994); spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

Spring-run Chinook salmon 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 feet/second to 3.5 feet/second (0.37 to 1.07 meters/ second), and water depths greater than 0.5 feet (0.15 m) (YCWA *et al.* 2007). The upper preferred water temperature for spawning Chinook salmon is 13 ºC to 14 ºC (55ºF to 57ºF) (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, CDFG 2001). Chinook salmon are semelparous (die after spawning).

3. Eggs and Fry Incubation to Emergence

The CV spring-run Chinook salmon 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 CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated inter-gravel environs where water temperatures range from about 5 to 13ºC (41 to 55.4ºF) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, emerging 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 intra-gravel flow. The optimal water temperature for egg incubation ranges from 5 ºC to 14 ºC (41ºF to 56ºF) (NMFS 1997, Rich 1997, Moyle 2002). A significant reduction in egg viability occurs at water temperatures above 14 ºC (57.5ºF) and total embryo mortality can occur at temperatures above 17 ºC (62ºF) (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16ºC and 3ºC (61ºF and 37ºF), 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 of the eggs.

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. 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). 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. Fry typically range from 25 mm to 40 mm (1 inch to 1.6 inches) 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. Many also will disperse downstream during high-flow events. 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

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 (2 to 2.25 inches), 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 9 feet to 10 feet in depth (2.7 m to 3.5 m), juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational 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 (movement at sunrise and sunset). 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 juveniles and hydrologic conditions. Kjelson *et al*. (1982) found that Chinook salmon fry travel as fast as 30 km per day (18.6 miles/ 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).

Since spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002), their emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings, depending on maturation rates and environmental conditions. The modal size of fry migrants at approximately 40 mm (1.6 inches) 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 CV spring-run Chinook salmon 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 CV spring-run Chinook salmon 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 California Department of Fish and Game (1998) observed the emigration period for spring-run Chinook salmon 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 CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run Chinook salmon 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, Sommer *et al*. 2001, MacFarlane and Norton 2002). Shallow water habitats 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 12ºC to 14 ºC (54ºF to 57ºF) (Brett 1952).

5. Estuarine Rearing

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 meters 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. 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 zooplankton 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 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 CV 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 CV 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 4. 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]					▒	▒	▒	▒	■	■	■	■	▒	▒	▒	▒	▒	▒	░					
Sac. River Mainstem[b,c]		░	░	░	▒	▒	▒	▒	▒	▒	▒	▒		▒	░	░								
Mill Creek[d]					░	░	▒	■	■	■	■	▒	▒	░	░									
Deer Creek[d]					░	░	▒	■	■	■	■	▒	▒											
Butte Creek[d,g]			░	▒	▒	▒	▒	■	■	■	■	▒	░											
(b) Adult Holding[a,b]				░	░	▒	▒	■	■	■	■	■	■	■	■	▒	▒	░	░					
(c) Adult Spawning[a,b,c]															░	▒	■	■	▒	░				

(d) Juvenile migration																								
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River Tribs[e]	▒	▒	▒	▒	▒	▒													▒	▒	■	■	■	■
Upper Butte Creek[f,g]	■	■	■	■	▒	▒	▒	▒	▒	▒	░	░							░	░	░	░	■	■
Mill, Deer, Butte Creeks[d,g]	■	■	■	■	▒	▒	▒	▒	▒	▒	░	░							░	░	░	░	░	░
Sac. River at RBDD[c]	■	■	░	░	░	░	░	░	░												■	■	■	■
Sac. River at KL[h]	▒	▒	▒	▒	■	■	■	■	▒	▒											▒	▒	■	■

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

2.2.2.4 Description of VSP Parameters for CV spring-run Chinook salmon

1. Abundance

Historically CV spring-run Chinook salmon 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 (1,000 to 6,000 feet, 305 to 1830 meters) 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 Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat in the upper San Joaquin River basin. The San Joaquin River population of spring-run Chinook salmon was extirpated in the late 1940’s when the Friant –Kern canal began water deliveries from Friant Dam, causing the tailwaters below the dam to dry up several miles downstream due to insufficient releases to maintain river connectivity (Skinner 1958).

The FRFH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 [California Department of Water Resources (CDWR) 2001]. However, after 1981, CDFG (now California Department of Fish and Wildlife (CDFW)) ceased to estimate in-river spawning spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. Spring-run Chinook salmon 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 (CDFG Grandtab 2013). Genetic testing has indicated that substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (CDWR 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 Chinook salmon stock (CDFG and CDWR 2012, Good *et al*. 2005). In addition, coded-wire tag (CWT) information from these hatchery returns has indicated that fall-run and spring-run Chinook salmon have overlapped (CDWR 2001). For the reasons discussed above, the FRFH spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem very difficult to determine, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; 2012 observed zero redds, and 2013, 57 redds in September (CDFG, unpublished data, 2014). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (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 CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remained well below estimates of historic abundance.

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C (69.8°F) for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the diseases.

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 2011). 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 2011b). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased, in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 appears to be lower, just over 5,000 fish, which indicates 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. CRRs 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. The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown, however the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive.

Table 5. Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2013) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.54	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									
Median	10,962	3,734	6,508	6,324	2.08	1.83	10,258	1.00	1.29

[a] NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.

[b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

3. Spatial Structure

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (figure 6) (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.

Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2013 unpublished data). 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 Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult spring-run Chinook salmon (Anderson *et al*. 2007). Genetic testing is needed to confirm that these fish are indeed spring-run Chinook salmon. Finally, rotary screw trap (RST) data provided by Stockton USFWS corroborates the spring-run Chinook salmon adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration.

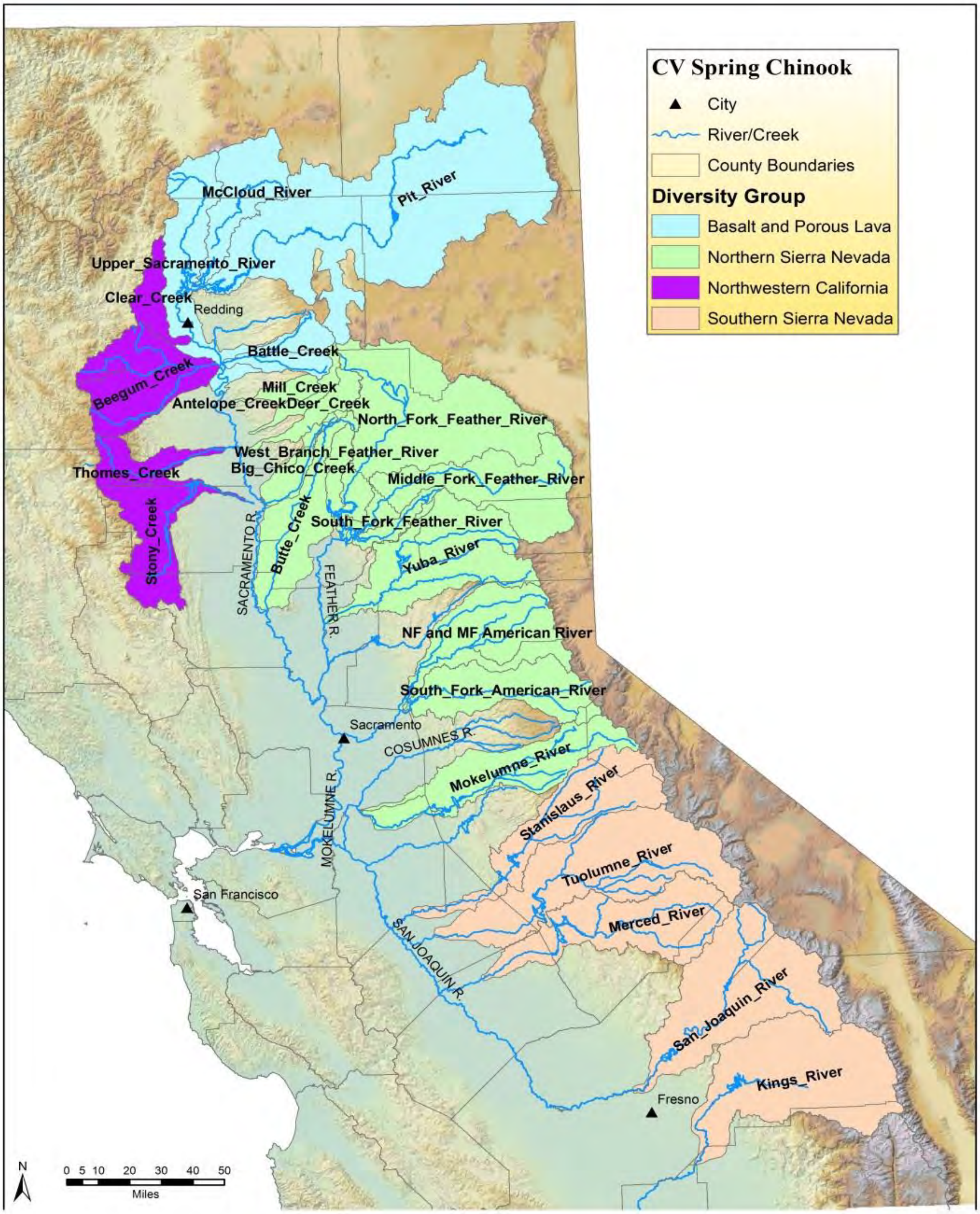


Figure 6. Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

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

In addition to the potential natural population of CV spring-run in the San Joaquin River basin described above, attempts to reintroduce an experimental population to the basin is underway. A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the San Joaquin River Restoration Project (SJRRP) (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 CV spring-run Chinook salmon within the experimental population area, and in specific instances elsewhere. The first release of CV spring-run Chinook salmon juveniles into the San Joaquin River occurred in April, 2014. 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 CV spring-run Chinook salmon ESU has yet to be determined.

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

4. Diversity

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

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

Until 2012, the status of CV spring-run Chinook salmon 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 Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams *et al*. 2011). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

2.2.3 CCV Steelhead DPS

- Originally listed as threatened on March 19, 1998 (63 FR 13347)
- Reaffirmed as threatened August 15, 2011 (76 FR 157)
- Critical habitat designated September 2, 2005 (70 FR 52488)

The Federally listed DPS of CCV steelhead and designated critical habitat occurs in the action area and may be affected by the proposed Project.

2.2.3.1 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 Feather River Hatchery and CNFH 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 2011c). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488).

2.2.3.2 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 7). Currently the CCV steelhead DPS and critical habitat extends up the San Joaquin River up 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 and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PBFs for CCV steelhead.

1. <u>Spawning Habitat</u>

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.

2. Freshwater Rearing Habitat

Freshwater rearing sites for CCV steelhead have the same attributes that have previously been described for the CV spring-run Chinook salmon in section 2.2.2.2 *Critical Habitat and Physical and Biological Features (PBFs) for CV Spring-run Chinook* salmon. Freshwater rearing habitat for CCV steelhead 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

Freshwater migration corridors for CCV steelhead have the same attributes that have previously been described for the CV spring-run Chinook salmon in section 2.2.2.2 *Critical Habitat and Physical and Biological Features (PBFs) for CV Spring-run Chinook* salmon. 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.

Figure 7. California Central Valley steelhead designated critical habitat.

2.2.3.3 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, NMFS 1996).

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

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 (cited in 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 in the California Central Valley (Table 6).

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 (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 Central Valley steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

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

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

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

Few direct counts of fecundity are available for CCV steelhead populations, but 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 (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 CNFH 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 CNFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock

(1989) reported for CNFH in the 1971 season, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider *et al*. 1986).

Table 6. The temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

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

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

Relative Abundance: █ = High ▓ = Medium ░ = Low

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

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).

2.2.3.4 Description of VSP Parameters

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 long term adult escapement monitoring plan is being planned (Eilers *et al*. 2010).

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

CNFH operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the Central Valley DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, CNFH stopped transferring all adipose-fin clipped steelhead above the weir, resulting in a large decrease in the overall numbers of steelhead above the weir in recent years (Figure 8). In addition, in 2003, CNFH transferred about 1,000 clipped adult steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery and natural-origin steelhead in Battle Creek were not differentiable, and all steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin steelhead in Battle Creek began in 2001. These estimates of steelhead abundance include all *O. mykiss*, including resident and anadromous fish (Figure 8).

Steelhead returns to CNFH have fluctuated greatly over the years. From 2003 to 2012, the number of hatchery origin adults has ranged from 624 to 2,968. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose clipped). 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 9).

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 10; data from USFW), and an average of 154 redds have been counted on the American River from 2002-2010 (Figure 11; 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 Feather River Hatchery have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 12). 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(CDFG) shows a slight rebound in numbers, with 712 adults returning to the hatchery through April 5th, 2011.

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 10). 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 (CDFG; ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure 13). The percentage of unclipped steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

The years 2009 and 2010 showed poor returns of steelhead to the Feather River Hatchery and CNFH, 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.

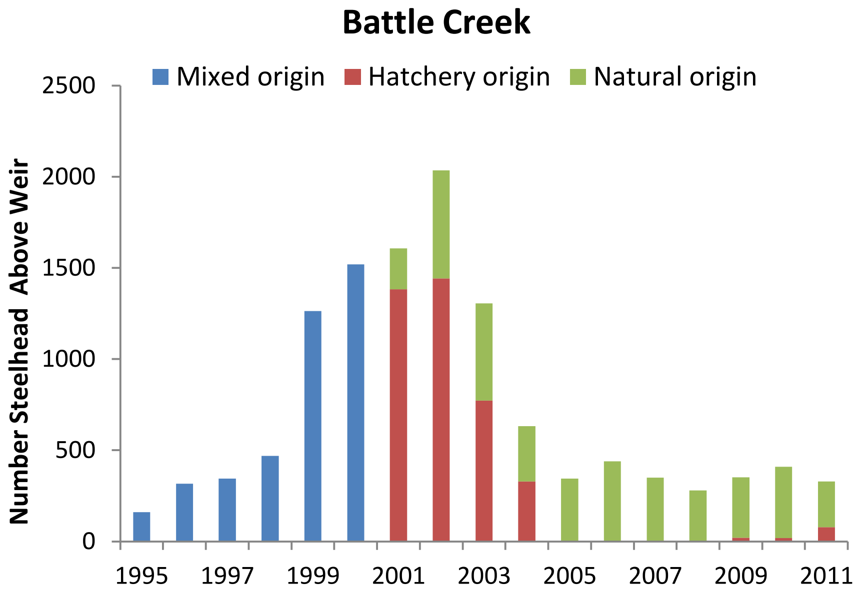


Figure 8. Steelhead returns to Battle Creek from 1995-2009. Starting in 2001, *O. mykiss* were classified as either wild (unclipped) or hatchery produced (clipped). Includes fish passed above the weir during broodstock collection and fish passing through the fish ladder March 1 to August 31. Data are from USFWS.

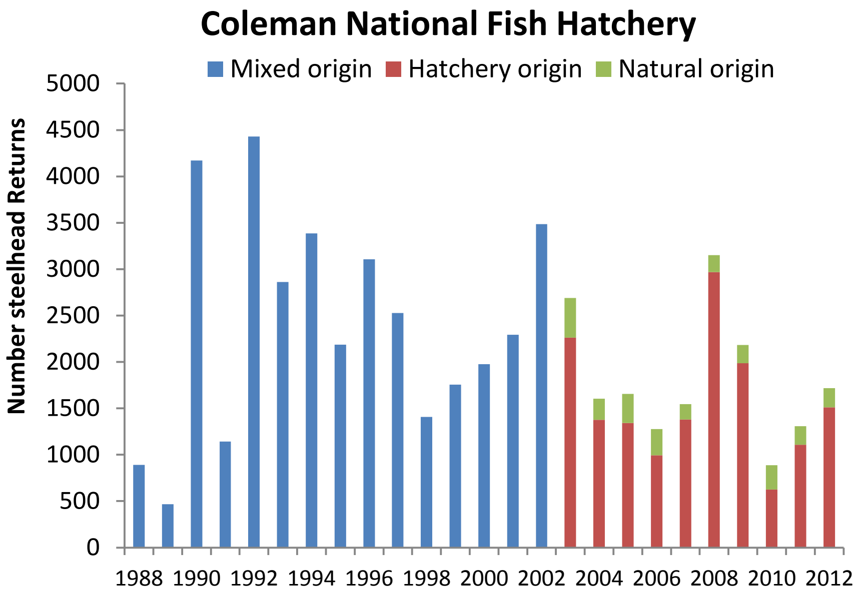


Figure 9. Annual steelhead returns to Coleman National Fish Hatchery. Adipose fin-clipping of hatchery smolts started in 1998 and since 2003 all returns have been categorized as either natural or hatchery origin.

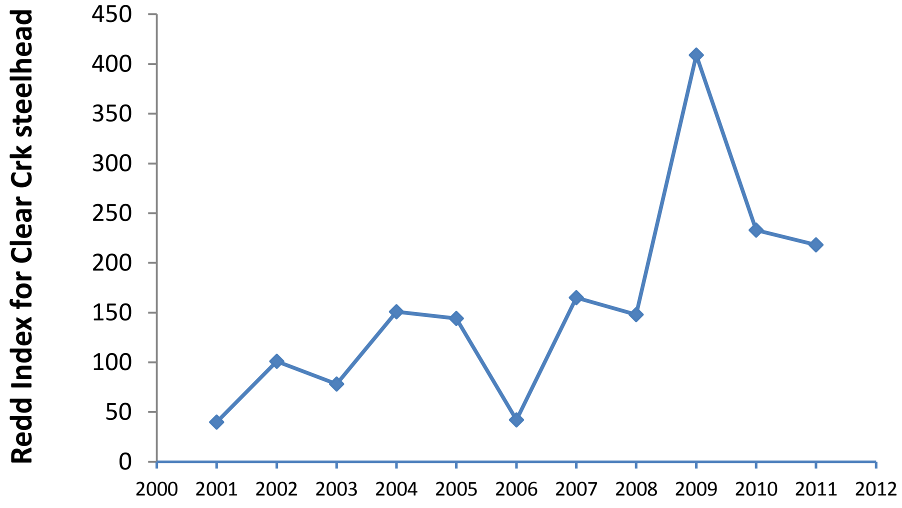


Figure 10. Clear Creek steelhead redd counts from USFWS surveys 2001–2011.

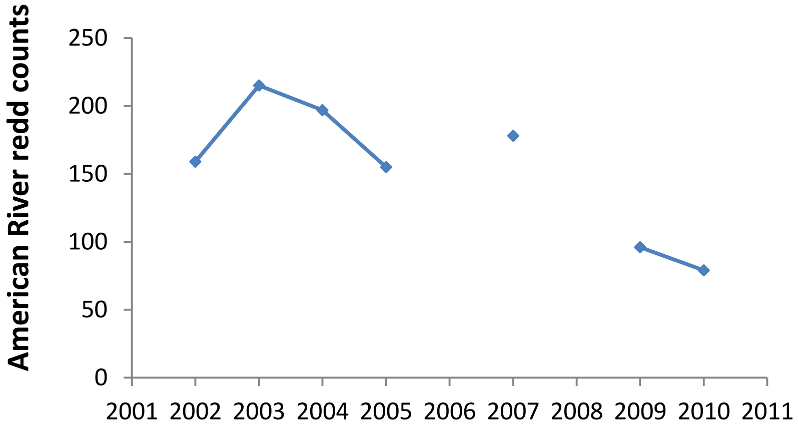


Figure 11. American River steelhead redd counts from USBR surveys 2002–2010. Surveys could not be conducted in some years due to high flows and low visibility.

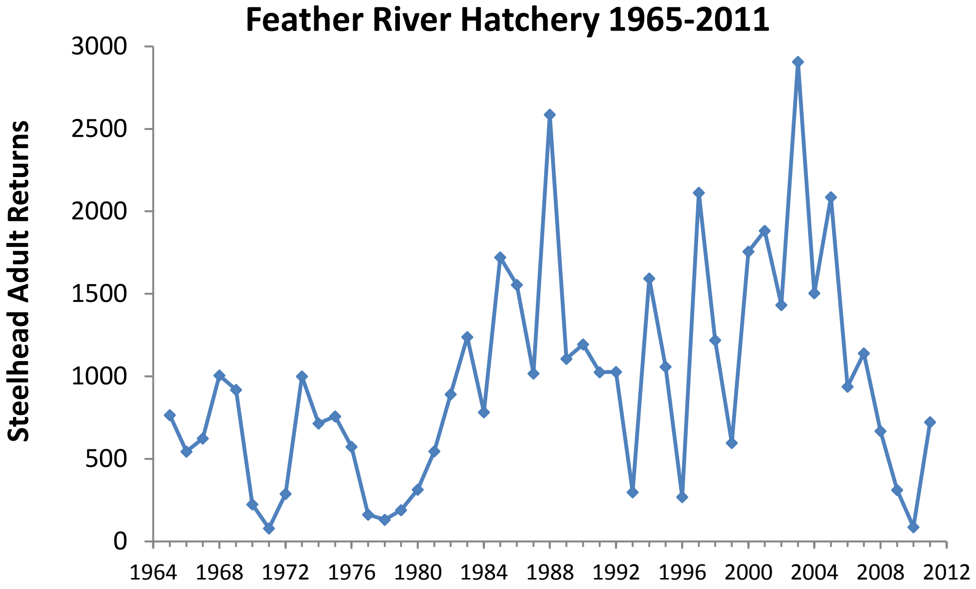


Figure 12. Feather River Hatchery steelhead returns 1965–2011. Almost all fish are hatchery origin.

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 these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams *et al*. 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. 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, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011c). 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.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities also indicates a reduction in the natural production of steelhead (Figure 13). The percentage of unclipped juvenile steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (NMFS 2011c).

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural steelhead production has continued to decline, and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Beginning in 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. The proportion of hatchery fish exceeded 90 percent in 2007, 2010, and 2011 (Figure 14). 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.

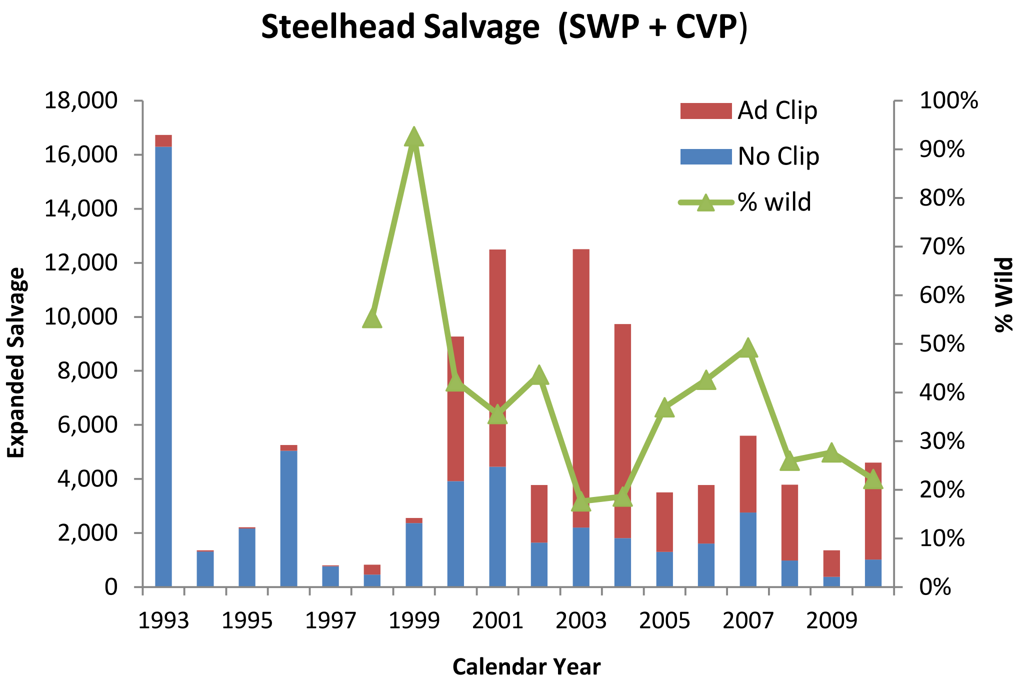


Figure 13. Steelhead salvaged in the Delta fish collection facilities from 1993 to 2010. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFG, at: ftp.delta.dfg.ca.gov/salvage.

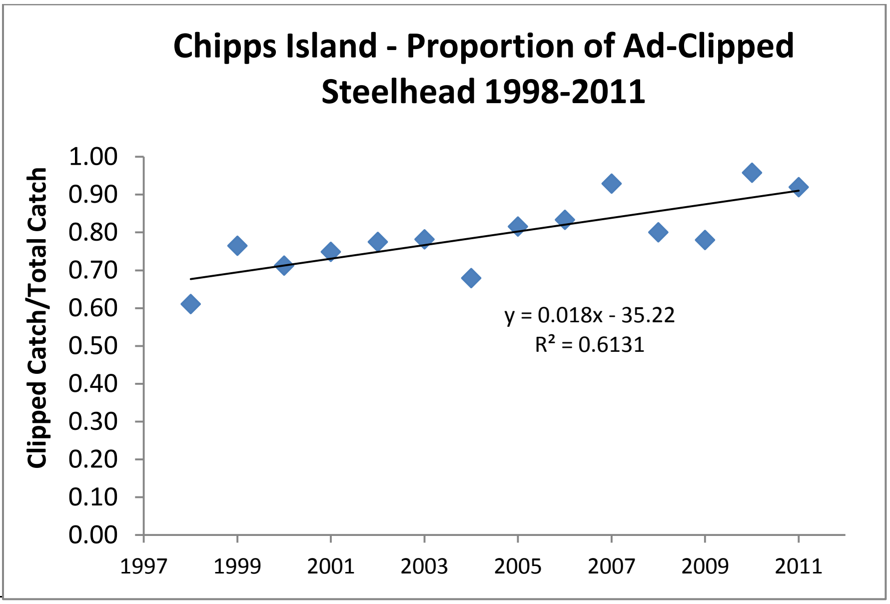


Figure 14. Catch of steelhead at Chipps Island in the USFWS midwater trawl survey 1998–2011. Fraction of the catch bearing an adipose fin clip. All hatchery steelhead have been marked starting in 1998.

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

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*. 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al*. 2005; NMFS 2011c). 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 rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer Fish Sciences 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected *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, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps 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 the rotary screw traps 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. Annual Kodiak trawl surveys are conducted on the San Joaquin River 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.

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

4. Diversity

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

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

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, Seelbach 1993). 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 rotary screw traps 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 (270 to 350 mm FL), 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 2011c); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock. Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

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

The widespread distribution of wild CCV steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV steelhead populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011c). 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 2011c) 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 sDPS of North American Green Sturgeon

- Listed as threatened on April 7, 2006, (71 FR 17757)
- Critical Habitat designated on October 9, 2009, (74 FR 52300)

The Federally listed sDPS of North American green sturgeon and designated critical habitat occurs in the action area and may be affected by the proposed Project.

2.2.4.1 Species Listing and Critical Habitat History

Green sturgeon (*Acipenser medirostris*) are broken into two distinct population segments (DPSs), a northern DPS (nDPS) and a southern DPS (sDPS), and while individuals from the two DPS's are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed, nor do they utilize the spawning areas of each other's natal rivers. The sDPS of North American green sturgeon presently contains only a single spawning population within the Sacramento River basin, primarily in the main stem Sacramento River below Keswick Dam but spawning has been documented to occur in the Feather River below Oroville Dam and potentially in the Yuba River where adults exhibiting spawning behavior have been observed. Adults and juveniles occur within the Delta and both life history stages may occur within the action area at any time of the year.

In June of 2001, NMFS received a petition to list green sturgeon under the ESA and to designate critical habitat. 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 information, taking into account rapidly developing new information. In April of 2005, NMFS (2005) revised its “not warranted” decision and proposed to list the sDPS of North American green sturgeon as “threatened”. In its 2006 final decision to list sDPS North American green sturgeon (also referred to as sDPS green sturgeon in this document) as threatened, NMFS cited concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats with regard to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities (71 FR 17757). Since the original 2006 listing decision, new information has become available that reinforces the original reasons for listing and reaffirms NMFS concerns that sDPS green sturgeon face substantial threats, challenging their recovery. Critical habitat was designated for the Southern DPS of North American green sturgeon on October 9, 2009 (74 FR 52300). A five-year review of the species was issued in August 2015, and finds that the sDPS of North American green sturgeon should remain listed as threatened under the ESA and that many of the listing factors remain unchanged since the initial listing.

2.2.4.2 Critical Habitat and PBFs for sDPS green sturgeon

Critical habitat for sDPS green sturgeon is defined as specific areas that contain the primary PBFs and physical habitat elements essential to the conservation of the species. Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line except for certain excluded areas. Critical habitat also includes the main stem Sacramento River from the I Street Bridge in Sacramento (the beginning of the Delta) upstream to Keswick Dam, and the Feather River from its confluence with the Sacramento River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery. Coastal Marine areas include waters out to a depth of 60 meters (~200 feet) from Monterey Bay, California, to the Juan De Fuca Straits in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for sDPS of North American green sturgeon (Figure 15).

1. <u>Freshwater riverine systems</u>:

    a. Food Resources

Food resources are drifting and benthic invertebrates, forage fish, and fish eggs. Although specific information on food resources for green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey as other sturgeons (Israel and Klimley 2008), such as the population of white sturgeon present and coexisting with green sturgeon in the Sacramento basin. 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). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of white sturgeon (Muir *et al*. 2000).

b. Substrate Type or Size

Substrate type consists of pockets of sand and gravel (2.0 to 64.0 mm in size) within the crevices of larger substrate, such as cobble and boulders (Poytress *et al*. 2011). Eggs are likely to adhere to sand and gravel after settling into crevices 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).

c. Water Flow

Water flow regimes consist of stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (14 – 17.5°C; 57.2 – 63.5°F) (Mayfield and Cech 2004, Van Eenennaam *et al*. 2005, Allen *et al*. 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs (~400 m^3s^{-1}) [average daily flows during spawning months range from 6,900 – 10,800 cfs (195 to 306 m^3s^{-1}); Brown (2007)]. In Oregon's Rogue River, green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 10°C (50°F) and flows increased (Erickson *et al*. 2002). On the Klamath River, the fall outmigration of green sturgeon (nDPS) has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al*. 2007). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

d. 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.

e. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. This PBF is highly degraded compared to its historical condition due to man-made barriers and alteration of habitat. Keswick Dam, at RM 302 (RKM 486), forms a complete barrier to any potential sturgeon migration on the Sacramento River, but downstream of this point, good spawning and rearing habitat exists, primarily in the river reach between Keswick Dam and

RBDD (RM 242; RKM 389.5). 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.

f. Depth

Deep pools of more than five meter depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River above the Glen Colusa Irrigation District (GCID) diversion. The significance and purpose of these aggregations are unknown at the present time, but may be a behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al*. 2002, Benson *et al*. 2007). As described above approximately 54 pools with adequate depth have been identified in the Sacramento River above the GCID location (Thomas *et al*. 2013).

g. 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), PAHs, and organochlorine pesticides] that can result in negative effects on any life stage of green sturgeon or their prey. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of green sturgeon.

2. Estuarine areas:

a. 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 the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within bays and estuaries.

b. 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. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the Bay and to initiate upstream spawning migrations.

c. 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 necessary for green sturgeon are discussed in detail in the life history section.

d. 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. Fish need the ability to freely migrate from the river through the estuarine waterways of the delta and bays and eventually out into the ocean. The sDPS green sturgeon 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 also utilized for rearing and holding, and these areas too must offer safe and unobstructed migratory corridors.

One of the key areas of concern is the Yolo and Sutter bypasses. These leveed floodplains are engineered to convey floodwaters of the greater Sacramento Valley and they include several concrete weir structures that allow flood flows to escape into the bypass basins. Adult sturgeon are attracted into the bypasses by these high flows. However the weirs can act as barriers and block the passage of fish back into the mainstem Sacramento River above the bypasses. Fish can also be trapped in the bypasses as floodwaters recede (USFWS 1995, CDWR 2005). Some of the weir structures have been designed with fish ladders to provide upstream adult salmon passage but these ladders have shown to be ineffective for providing upstream passage to adult sturgeon (CDWR and BOR 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 and can impede fish passage. As a result, sturgeon may become stranded in the bypasses and face delayed migration and lethal and sub-lethal effects from poaching, high water temperatures, low dissolved oxygen, and desiccation.

e. Water Depth

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy deep (more than 5 meters; 16.4 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 10 meters (33 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 (~1 to 2.4 m) deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966).

f. Sediment Quality

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

3. Coastal Marine Areas

The PBFs for coastal marine areas are omitted from this document as the focus here is upon 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).

4. Critical Habitat Summary

The current condition of critical habitat for sDPS green sturgeon is degraded over its historical condition. In particular, migratory corridors in freshwater riverine and estuarine areas and water flow PBFs have been particularly impacted by human actions, substantially altering the historical environmental characteristics in which sDPS green sturgeon evolved. However, even in their degraded state, the PBFs in the freshwater riverine systems and estuarine areas provide important benefits to sDPS green sturgeon and have a high conservation value.

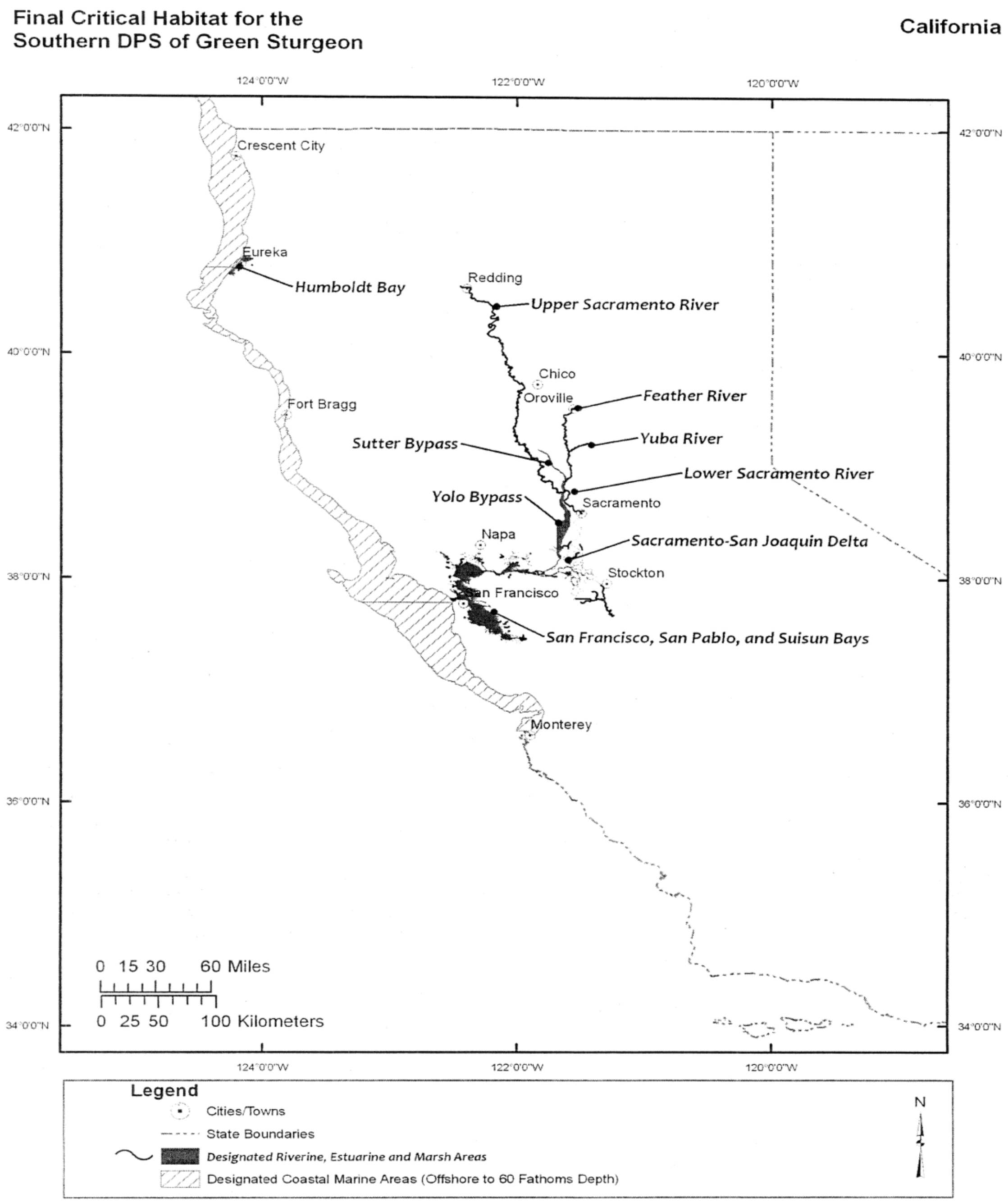


Figure 15. Green sturgeon critical habitat in California. Source: 50 CFR 226.219

2.2.4.3 Green Sturgeon Life History

1. General Information

Green sturgeon are a species of ancient fish, highly adapted to benthic environments, and very marine oriented, entering freshwater mainly to spawn, but residing in bays, estuaries, and near coastal marine environments for the vast majority of their lifespan. They are known to be long lived; green sturgeon captured in Oregon have been age-estimated up to 52 years old, using a fin-spine analysis (Farr and Kern 2005). They are iteroparous, meaning they can spawn multiple times within their lifespan. The details of their biology are described in the life history section of this document, and also 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 given in Table 7. There is considerable variability across categories, such as size or age at maturity.

2. Adult Migration and Spawning

Various studies of spawning site characteristics (Poytress *et al.* 2011, Thomas *et al.* 2013, and Mora unpublished data) agree that spawning sDPS green sturgeon typically favor deep, turbulent holes over 5 meters deep (~16 feet), featuring sandy, gravel, and cobble type substrates. The necessity for deep water depth may be flexible, as spawning has been documented in depths as shallow as 2 meters (~6.5 feet) (Poytress *et al.* 2011). However, substrate type is likely constrained as the interstices of the cobble and gravel catch and hold the adhesive eggs, allowing them to incubate without being washed downstream. Flows need to be high enough to create the deep, turbulent habitat that green sturgeon favor for spawning. Successful egg development requires a water temperature range between 11° C (51.8°F) and 19° C (66.2°F).

Most green sturgeon spawning activity occurs on the mainstem Sacramento River, although not all sites are known. Poytress *et al.* (2012) conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 that identified a number of confirmed spawning locations and potential spawning locations (Figure 16). It was found that just 3 of these spawning sites on the Sacramento River accounted for over 50 percent of green sturgeon spawning activity (Mora unpublished data).

Post spawning, adults have been observed to either leave the system rapidly, or to hold in deep pools and migrate downriver in late fall or early winter after the first storms. 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: upstream spawning migration, spring outmigration to the ocean, summer holding, and outmigration after summer holding. Following spawning, sDPS green sturgeon typically re-enter the ocean generally from November through January (with the onset of the first winter storms), with migration through the estuary lasting about a week.

Table 7. General green sturgeon life history from egg to adult including length-life stage information.

Timeline	**Life stage, Length-age relationship**
Fertilization of eggs (spawning)	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) after fertilization of eggs	Newly hatched larvae emerge. **Larvae are 12.6 – 14.5 mm** in length[4]
6 days post hatch (dph)	Nocturnal swim up, hide by day behavior observed[4]
10 dph	Exogenous feeding begins around 10 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 900 mm**. Little information available about this life stage.
1.5 – 4 years	Juveniles migrate to sea for the first time, 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*	Green sturgeon reach sexual maturity and become adults, with **males maturing around 120 cm and females maturing around 145 cm[5]**
15 years to 50+ years	Green sturgeon have a lifespan that can reach 50 or more years, and can grow to a **total length of over 2 meters**

Sources:
1. Thomas *et al.* (2013) 2. Ethan Mora, UC Davis, 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. More research is needed to determine the typical age and size of sDPS green sturgeon at maturity.

Table 8. Migration timing of sDPS green sturgeon by location and life stage

				░ Low	▒ Medium	▓ High	▒ Medium	░ Low				

a) Spawning adults

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry, heading upstream	░	▓	▓	▓	░							
Arrival at Rio Vista, heading upstream	░	▓	▓	▓	░							
Arrival to spawning grounds on upper Sacramento River		░	▓	▓	▒	░						
Sacramento River spawning period				▒	▓	▓	░					
Sacramento River upriver presence	▓	░	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Arrival at Rio Vista, heading downstream	▓	░						░		░		▓
Arrival at Golden Gate, heading seaward	▓	░								▒		▓

b) Summer and fall residence of subadults and non-spawning adults in the San Francisco Bay Estuary

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry				▒	▒	▓	▓	▒				
Residing in estuary				▒	▓	▓	▓	▓	▓	▒	░	
Golden Gate departure				░	░	▓	░	▒	▓	▒	░	

c) YOY/Juveneiles

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
YOY at Red Bluff Diversion Dam					▓	▓	▓	░	░			
YOY at GCID					▒	▓	▓	▒	░			
Juveniles from Delta salvage (<50cmTL)		░	▒	░	░	░	░	▓	░	▒	▒	░
Juveniles residing in San Francisco Bay Estuary	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓

3. Egg and Larval Stages

Green sturgeon fecundity is approximately 50,000–80,000 eggs per adult female (Van Eenennaam *et al*. 2001) and have the largest egg size of any sturgeon species. The outside of the eggs (chorion) are adhesive, and the eggs are denser than those of white sturgeon (Kynard *et al*. 2005, Van Eenennaam *et al*. 2009). Green sturgeon larvae hatch 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). Temperatures over 23 °C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching. 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. At incubation temperatures below 14°C (57.2°F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam *et al.* 2005). Table 9 shows temperature tolerance by life stage for all stages of green sturgeon development.

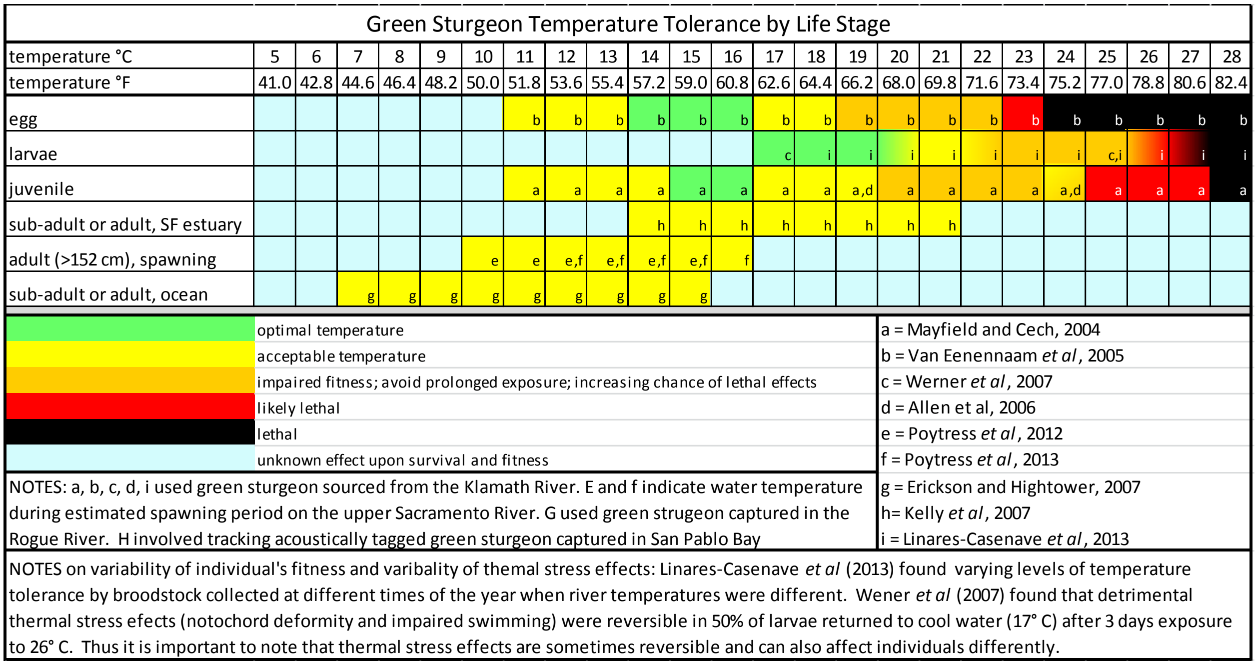
Newly hatched green sturgeon are approximately 12.5mm to 14.5 mm (0.5 to 0.57 inches) in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. These yolksac larvae are less developed in their morphology than older juveniles and external morphology resembles a "tadpole" with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation.

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al.* 2002) and are approximately 75 mm (2.95 inches) in length. At this stage of development, the fish are considered juveniles and are no longer larvae.

Larval green sturgeon hatch in the late spring or summer (peak in July) and progress downstream towards the Delta rearing into juveniles. Information about larval sDPS green sturgeon in the wild is very limited. USFWS conducts annual sampling for eggs and larvae in the mainstem Sacramento River. Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other Acipenseridae. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Larval green sturgeon appear in USFWS rotary screw traps at the RBDD from May through August (Poytress *et al.* 2010) and at lengths ranging from 24 to 31 mm (0.95 to 1.22 inches) fork length, indicating they are approximately two weeks old (CDFG 2002, USFWS 2002). USFWS data reveals some limited information about green sturgeon larvae, such as time and date of capture, and corresponding river conditions such as temperature and flow parameters. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8°C (46.4°F), downstream migrational behavior diminished and holding behavior increased. These data suggest that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. It is unknown when they enter the Delta, but once reaching the Delta typically rear for 2–3 years before entering the ocean.

Unfortunately, there is little information from the wild regarding diet, spatial distribution, riverine habitat preferences, travel time through the river, and estuary rearing preferences for habitat type. Although laboratory studies have provided some information about this initial life stage, the relevance to fish in their natural habitat is unverified. Probably the most significant use of the USFWS data on larval green sturgeon has been to infer larval growth rates and correlations of these growth rates to temperature and flow conditions, allowing comparisons with larval green sturgeon growth rates in other river systems such as the Klamath and Rogue rivers.

Table 9: Green sturgeon temperature tolerance range by life stage



Green Sturgeon Temperature Tolerance by Life Stage																								
temperature °C	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
temperature °F	41.0	42.8	44.6	46.4	48.2	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4
egg							b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
larvae													c	i	i	i	i	i	i	i	c,i	i	i	i
juvenile							a	a	a	a	a	a	a	a	a,d	a	a	a	a	a,d	a	a	a	a
sub-adult or adult, SF estuary										h	h	h	h	h	h	h	h							
adult (>152 cm), spawning						e	e	e,f	e,f	e,f	e,f	f												
sub-adult or adult, ocean			g	g	g	g	g	g	g	g	g													

🟩	optimal temperature	a = Mayfield and Cech, 2004
🟨	acceptable temperature	b = Van Eenennaam *et al*, 2005
🟧	impaired fitness; avoid prolonged exposure; increasing chance of lethal effects	c = Werner *et al*, 2007
🟥	likely lethal	d = Allen et al, 2006
⬛	lethal	e = Poytress *et al*, 2012
🟦	unknown effect upon survival and fitness	f = Poytress *et al*, 2013

NOTES: a, b, c, d, i used green sturgeon sourced from the Klamath River. E and f indicate water temperature during estimated spawning period on the upper Sacramento River. G used green strugeon captured in the Rogue River. H involved tracking acoustically tagged green sturgeon captured in San Pablo Bay

g = Erickson and Hightower, 2007
h= Kelly *et al*, 2007
i = Linares-Casenave *et al*, 2013

NOTES on variability of individual's fitness and varibality of themal stress effects: Linares-Casenave *et al* (2013) found varying levels of temperature tolerance by broodstock collected at different times of the year when river temperatures were different. Wener *et al* (2007) found that detrimental thermal stress efects (notochord deformity and impaired swimming) were reversible in 50% of larvae returned to cool water (17° C) after 3 days exposure to 26° C. Thus it is important to note that thermal stress effects are sometimes reversible and can also affect individuals differently.

4. Juvenile Development and Outmigration

Young green sturgeon appear to rear for the first one to two months in the Sacramento River (CDFG 2002). Growth is rapid as juveniles move downstream and reach up to 300 mm (11.8 inches) in fork length the first year and over 600 mm (23.6 inches) in fork length in the first 2 to 3 years (Nakamoto *et al*. 1995). Juvenile sDPS green sturgeon have been salvaged at the Federal and State pumping facilities located in the south Delta, and collected in sampling studies by CDFW during all months of the year (CDFG 2002). Salvage data have been updated through 2014 (Figure 17). The majority of juveniles that were captured in the Delta were between 200 and 500 mm (7.9 to 19.7 inches) long in fork length, indicating they were from 2 to 3 years of age, based on age/growth studies from the Klamath River (Nakamoto *et al*. 1995). The lack of any juveniles smaller than approximately 200 mm (7.9 inches) in the Delta suggests that smaller individuals rear upstream of the Delta. 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 (7.9 to 22.8 inches), further supporting the hypothesis that juvenile green sturgeon enter the Delta after 10 months or at 200 mm in size. Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance between 15°C (59°F) and 19°C (66.2°F) (Mayfield and Cech 2004).

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).

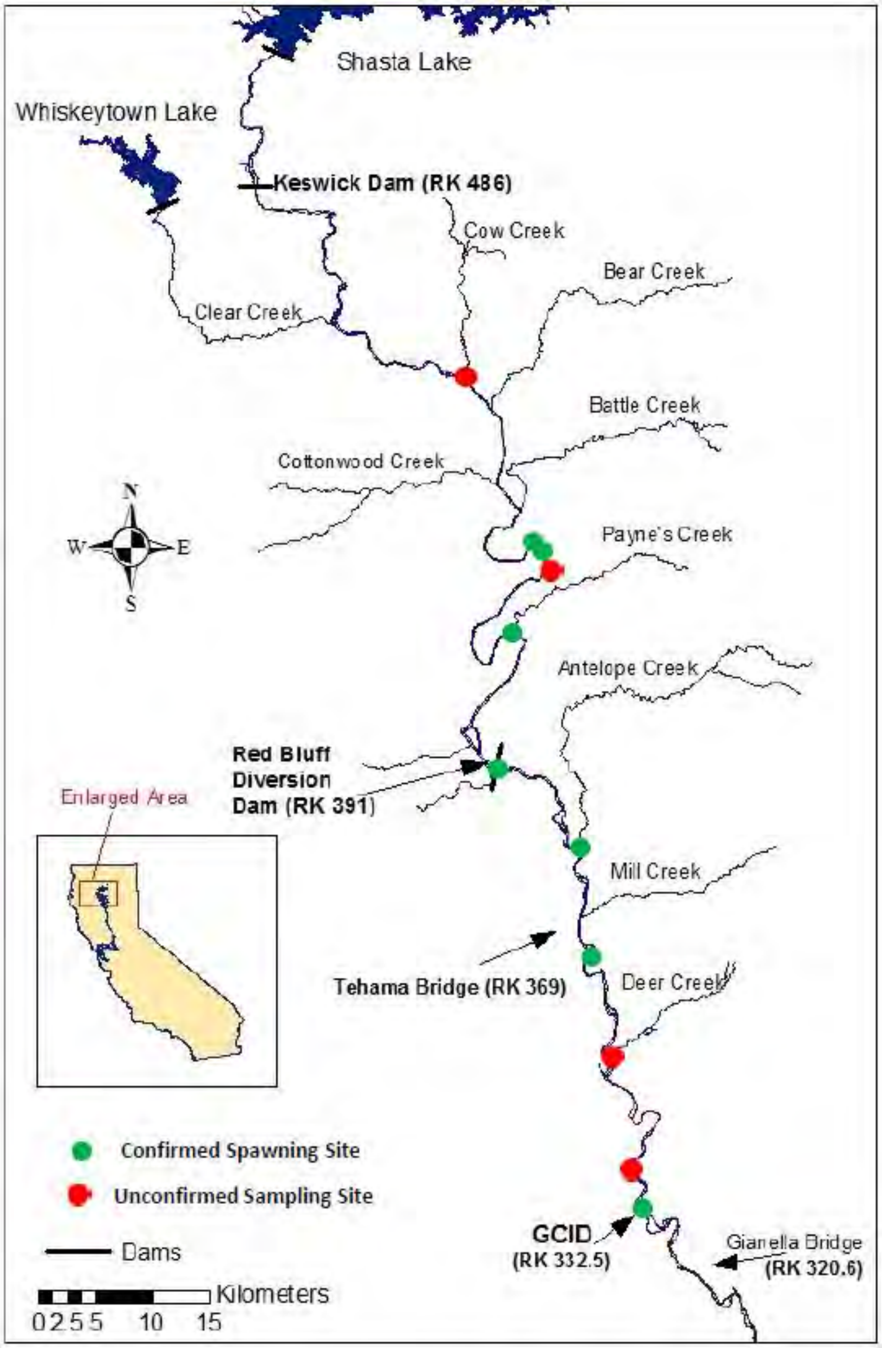


Figure 16: Green sturgeon spawning locations in the Sacramento River from 2008–2012. Source: Poytress *et al*. (2012). Unconfirmed sites indicate an area where sturgeon have been known to congregate but where evidence of spawning was not obtained in the study.

5. Estuarine Rearing

There is a fair amount of variability (2 – 3 years) in the estimates of the time spent by juvenile green sturgeon in fresh or brackish water before making their first migration to sea. Nakamoto *et* *al.* (1995) found that green sturgeon (nDPS) on the Klamath River migrated to sea, on average by age three and no later than age four. Moyle (2002) suggests juveniles migrate out to sea before the end of their second year, and perhaps as yearlings. Laboratory experiments indicate that green sturgeon juveniles may occupy fresh to brackish water at any age, but they gain the physiological ability to completely transition to saltwater at around 1.5 years of age (Allen and Cech 2007). Studying green sturgeon on the Klamath River, Allen *et al.* (2009) estimated the timing of transition from fresh water to brackish water to seawater by analyzing strontium to calcium ratios from the leading edge of the green sturgeon pectoral fins. The results of this study indicate that green sturgeon move from freshwater to brackish water (such as the estuary) at ages 0.5−1.5 years and then move into seawater at ages 2.5-3.5 years.

6. <u>Ocean Rearing</u>

Once green sturgeon juveniles make their first entry into the marine environment, they enter the sub-adult phase and spend a number of years migrating up and down the continental shelf along the west coast. Sub-adults mature in coastal marine environments and in bays and estuaries until at least 9–17 years of age before returning to their natal river to spawn. An individual may spawn once every 3 to 5 years and live for 50 years or more. While they may enter river mouths and coastal bays throughout their years in the sub-adult phase, they do not move upstream past tidewater and only move into freshwater when they return to their natal river to spawn as a mature adult.

In the summer months, multiple rivers and estuaries throughout the sDPS green sturgeon range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley *et al.* 2008, and 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 in all months of the year (Kelly *et al.* 2007, Heublein *et al.* 2009, Lindley *et al.* 2011).

2.2.4.4 Green Sturgeon Viable Population Parameters

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

1. <u>Abundance</u>

Currently, there are no reliable data on population sizes, and data on population trends are also lacking. Fishery data collected at the Skinner Fish Collection Facility (SFPF) and Tracy Fish

Collection Facility (TFCF) in the south Delta indicate a decreasing trend in abundance between 1968 and 2006 (70 FR 17386, Figure 17). Captures of larval green sturgeon in the RBDD RSTs have shown variable trends in spawning success in the upper river over the past several years and have been complicated by the operations of the RBDD gates during the green sturgeon spawning season in previous years. In 2011, a wet year in the Sacramento River, captures in the rotary screw trap have been substantially higher than in previous years (3,701 fish). The last strong year class, based on captures of larval sturgeon was in 1995. This would suggest that the 2011 year class for sDPS green sturgeon will be a strong year class. However, only 14 green sturgeon juveniles were salvaged in 2011, and none in 2012, 2013, and 2014, which suggests that this large population may not have successfully emigrated downstream to the Delta to rear. Recent captures of juvenile green sturgeon in the RBDD RST were 289 fish in 2012, and 443 fish in 2013. Estimates of spawning adult population size range from 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71) (Israel 2006b). More recently, Israel and May, (2010) estimated that 10-28 individual sDPS green sturgeon effectively reproduce above RBDD in the upper Sacramento River annually. Didson camera observations in 2010 and 2011 identified aggregations of (presumably) green sturgeon adults in the Sacramento River ranging between 164 and 245 individuals per observation cycle (Ethan Mora, UC Davis, unpublished data). Assuming that all of these observed sturgeons are truly green sturgeon adults, and adults spawn every 2 to 4 years, and using the population structure from Beamesderfer *et al*. (2007), the calculated estimate would be 328 to 980 adults and 1,722 to 5,145 subadults in the population. The estimated total population of juveniles, subadults, and adults combined ranges from 2,733 to 8,166 individuals.

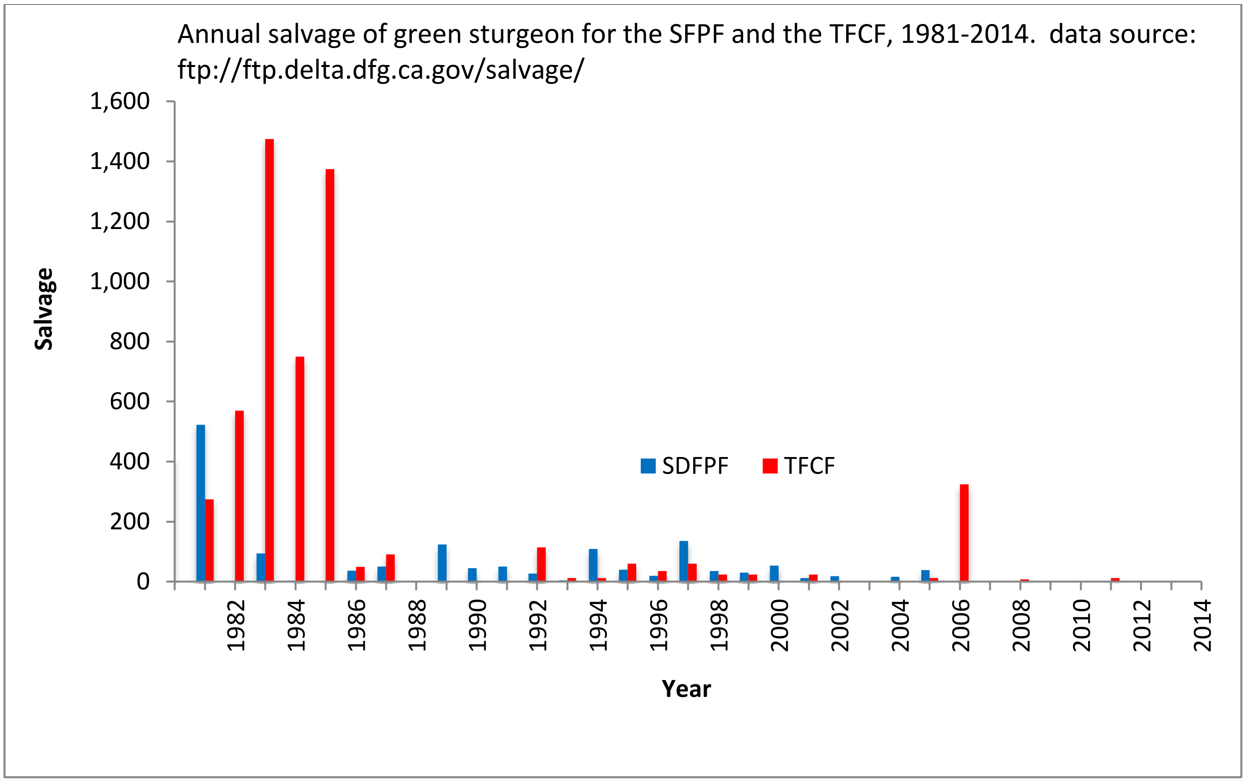


Figure 17. Annual salvage of green sturgeon for the SFPF and the TFCF 1981–2014. Data source: ftp://ftp.delta.dfg.ca.gov/salvage

In determining the conservation status of sDPS green sturgeon, a few notes with regards to population size are crucial. Population(s) should be large enough to survive environmental variations, catastrophes, and anthropogenic perturbations. Also, the population(s) should be sufficiently large to maintain long term genetic diversity (McElhany *et al.* 2000). Our understanding of the status of sDPS green sturgeon towards these concerns is developing.

2. Productivity

Productivity and recruitment information for sDPS green sturgeon is an area that requires additional research; existing data is too limited to be presented as robust estimates. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green sturgeon at the south Delta pumping facilities suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al.* 2007, Lindley *et al.* 2007). In general, sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010b). It is unclear if the population is able to consistently replace itself. This is significant because the VSP concept requires that a population meeting or exceeding the abundance criteria for viability should, on average, be able to replace itself (McElhany *et al.* 2000). More research is needed to establish sDPS green sturgeon productivity.

3. Spatial Structure

Green sturgeon, as a species, are known to range from Baja California to the Bering Sea along the North American continental shelf. During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett 1991, Moser and Lindley 2007). Based on genetic analyses and spawning site fidelity (Adams *et al.* 2002, Israel *et al.* 2004), green sturgeon are comprised of at least two DPSs.

a. A nDPS consisting of populations originating from coastal watersheds northward of and including the Eel River (*i.e.* Klamath, Rogue, and Umpqua rivers), and
b. A sDPS consisting of populations originating from coastal watersheds south of the Eel River.

Throughout much of their range, sDPS and nDPS green sturgeon are known to co-occur, especially in northern estuaries and over-wintering grounds. However, those green sturgeon that are found within the inland waters of California are almost entirely sDPS green sturgeon (Israel and Klimley 2008).

Adams *et al*. (2007) summarizes information that suggests green sturgeon may have been distributed upstream of the locations of present-day dams on the Sacramento and Feather rivers. In the California CV, sDPS green sturgeon are known to range from the Delta to the Sacramento River up to Keswick Dam, the Feather River up to the fish barrier structure downstream of Oroville Dam, and the Yuba River up to Daguerre Point Dam. Additional habitat may have historically existed in the San Joaquin River basin. Anecdotal evidence from anglers suggest sDPS green sturgeon presence in the San Joaquin River. Since implementation of the Sturgeon Report Card in 2007, anglers have reported catching 169 white sturgeon and six green sturgeon on the San Joaquin River upstream from Stockton (Gleason *et al.* 2008; DuBois *et al.* 2009, 2010, 2011, 2012).

In applying the VSP concept to sDPS green sturgeon, it is important to look at the within-population spatial diversity. Ongoing research is being conducted to determine if the green sturgeon sDPS is composed of a single population, or perhaps several populations. It is known that sDPS green sturgeon spawn in the mainstem Sacramento River, the Feather River (Seeholtz *et al*. 2014), and potentially the Yuba River (Bergman *et al*. 2011); but it is not yet known if these spawning areas represent individual populations, sub-populations, or if they are all part of one single population. However, it is encouraging to note that at least this level of spatial diversity exists; when sDPS green sturgeon were originally listed as threatened under the ESA, the only known spawning locations at the time were those on the mainstem Sacramento River.

4. Diversity

The VSP concept identifies a variety of traits that exhibit diversity within and among populations, and this variation has important effects on population viability (McElhany *et al.* 2000). For sDPS green sturgeon, such traits include, but are not limited to fecundity, age at maturity, physiology, and genetic characteristics. On a species-wide scale, studies have examined the genetic differentiation between sDPS and nDPS green sturgeon (Israel *et al.* 2004). Within the sDPS, little is known regarding how current levels of diversity (*e.g.*, genetic, life history) compare with historical levels.

Although the population structure of sDPS green sturgeon is still being refined, it may be the case that only a single population exists. This may have the effect of providing for lower diversity than if two or more populations existed. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population.

5. Summary

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 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 is not believed to be viable. To support this statement, the population viability analysis (PVA) that was done for sDPS green sturgeon in relation to stranding events (Thomas *et al*. 2013) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley *et al*. (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (NMFS 2010a) and in the most recent 5-year review (NMFS 2015b) the listing under the ESA remains unchanged as threatened, as many of the threats cited in the original listing still exist.

2.2.5 Climate Change

One factor affecting the rangewide status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and sDPS green sturgeon, and aquatic habitat at large is climate change.

The world is about 1.3°F (0.72ºC) 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 [Intergovernmental Panel on Climate Change (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 to 1.0 m (1.6 to 3.3 feet) in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g.*, salt marsh, riverine, mud flats) affecting 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 more likely to occur and will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to overtake native fish species and impact predator-prey relationships (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 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by precipitation rather than snowfall. 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. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should 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 developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids that must hold below the dam over the summer and fall periods.

Currently, California is experiencing one of the worst droughts (2012–2015) in the last 83 years. Salmon, steelhead, and green sturgeon populations will likely experience lower juvenile survival due to poor freshwater conditions (*e.g.*, low flows, higher temperatures) caused by the drought.

Lethal water temperatures in the tailwaters below the rim dams have reduced the viability of eggs and larvae in the gravel for winter-run and CV spring-run Chinook salmon, and have made tributaries excessively warm over the summer and fall seasons due to a lack of snow pack and snow melt runoff which may affect juvenile CCV steelhead and yearling CV spring-run Chinook salmon survival. Early life stages of sDPS of North American green sturgeon are expected to be less affected by the increased temperatures in the waters in which they spawn due to their higher thermal tolerances in the early life stages compared to salmonids. However, they still may experience a lower survival rate and increased rates of larval malformations at these higher temperatures compared to cooler temperatures. Therefore, adult abundance is predicted to decline significantly in 2016–2018 for returning adult salmonids due to losses of juvenile fish incurred during their first year of life. Also, lower survival of sDPS green sturgeon during their juvenile life history stage are expected to result in lower adult spawner populations in future years. The ongoing drought will reduce juvenile populations of salmonids and sDPS green sturgeon entering the Delta during this year and for each brood year that continues to experience drought conditions.

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).

2.3.1 Status of the Species and Critical Habitat in the Action Area

2.3.1.1 Status of the Species within the Action Area

The action area functions primarily as a migratory corridor for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon, but it also provides some use as holding and rearing habitat for each of these species as well.

1. <u>Sacramento River Winter-Run Chinook Salmon</u>

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles within the action area (northern Delta) are best described by a combination of fish monitoring programs conducted in the northern and central Delta and the salvage records of the CVP and SWP fish collection facilities (see Tables 10, 11, and 12). Using the fish monitoring data from the northern and Central Delta, 3 percent of the annual winter-run juvenile population emigrates into the Delta in November, 24 percent in December, 17 percent in January, 19 percent in February, 37 percent in March and only 1 percent in April. The first entry of winter-run juveniles into the Delta (as measured by both the Knights Landing RST and the Sacramento Trawls monitoring data) can occur as early as the beginning of October (Tables 13 and 14). These early arrivals to the Delta typically coincide with precipitation events that produce a sharp spike in the Sacramento River hydrograph. Over a 12-year period (water years 2001 to 2012), approximately 4 percent of the annual cumulative catch at the Knights Landing RST occurred by the end of October and 10.7 percent by the end of November. Presence of juvenile winter-run at either the Knights Landing RST site or at the Sacramento River trawl site would be considered as evidence that these fish would be present in the action area, provided that the DCC gates remained open immediately prior to and during the rise in river levels. The timing of juvenile winter-run presence in the Delta is corroborated by the salvage records covering water years 2000 to 2009 at the CVP and SWP fish collection facilities which pertain to operations prior to the modifications of operations resulting from the biological opinions from the USFWS and NMFS for the long-term operations of the State and Federal water projects. Juvenile Sacramento River winter-run Chinook salmon are typically present in the action area starting no later than December, if not earlier, based on salvage in the South Delta. During the study period, a significant rain event may occur in the upper Sacramento River basin causing a sharp increase in the river flows in a 24-hour period or flows greater than approximately 400 cubic meters per second (m^3 s^{-1}) (approximately 14,000 cfs, del Rosario *et al*. 2013) as measured at Wilkins Slough near the Knights Landing RST site. If such an event occurs, considerable winter-run juvenile emigration is expected to occur, and they would be considered to be in the Delta and in the action area.

Presence of adult Chinook salmon in the Delta is interpolated from historical data derived from the upstream passage of adult fish past RBDD (Table 12). Assuming a migratory movement rate of 25 km per day, fish would be in the Delta approximately 2 weeks earlier than the dates at RBDD. Adult winter-run Chinook salmon are expected to enter the action area starting in January (~ 3 percent), with the majority of adults passing through the action area from February to the end of April (~ 66 percent). During the proposed study periods (October 3 through December 1, 2016) NMFS does not expect any of the adult winter-run spawning population to pass through the action area.

2. CV Spring-Run Chinook Salmon

A similar application of the CVP and SWP salvage records and the northern and Central Delta fish monitoring data to the presence of CV spring-run Chinook salmon indicates that juvenile spring-run Chinook salmon first begin to appear in the action area in December and January, but that a significant presence does not occur until March and peaks in April (17.2 and 65.9 percent of average annual salvage, respectively). By May, the salvage of juvenile CV spring-run Chinook salmon declines sharply and essentially ends by the end of June (15.5 and 1.2 percent of average annual salvage, respectively). The data from the northern and central Delta fish monitoring programs indicate that a small proportion of the annual juvenile spring-run emigration occurs in January (3 percent) and is considered to be mainly comprised of older yearling spring-run juveniles based on their size at date. Based on the Delta size criteria by date, the majority of CV spring-run Chinook salmon juveniles (young-of-the-year size) emigrate in March (53 percent) and April (43 percent) and tails off sharply by May (1 percent) and thus will be present in the action area during these periods (Tables 10, 11, and 12). This pattern is further supported and consistent with salmonid passage estimates derived from rotary screw trap data collected by USFWS in the upper Sacramento River, which indicate two significant peaks in the annual passage of juvenile CV spring-run Chinook salmon at RBDD occurring in the months of December and April. Using information from the Knights Landing RST operated by the CDFW, the first appearance of CV spring-run juveniles in the lower Sacramento area can happen as early as October, however these fish typically show up weeks later in the Sacramento River trawl (Tables 15 and 16). Based on the data from the Knights Landing RST, the cumulative annual catch by the end of September is 0 percent, 0.07 percent by the end of October, and 0.54 percent by the end of November. Adult CV spring-run Chinook salmon are expected to start entering the action area in approximately January. Low levels of adult migration are expected through early March. The peak of adult CV spring-run Chinook salmon movement through the action area in the Delta is expected to occur from April to June, with adults continuing to enter the system through the summer and early fall. There is the potential for adult spring-run to be present in the action area during September and October moving upriver to spawn.

3. CCV Steelhead

CCV steelhead smolts first start to appear in the action area no later than November based on the records from the CVP and SWP fish salvage facilities (water years 2000 – 2009), as well as the fish monitoring program in the northern and central Delta (Tables 10 and 11). Their presence increases through December and 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, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP. Data from the northern and central Delta fish monitoring programs indicate that steelhead smolts begin to enter the northern Delta as early as September through December, but do not substantially increase in numbers until February and March (Table 11). During the study periods (September 1 through November 13, 2015, and September 1 through November 12, 2016), less than 3 percent of the annual juvenile emigration through the Delta will likely occur. Adult steelhead are expected to move through the action area during the Project, as the peak of upriver immigration occurs from August through November on the Sacramento River (Mc Ewan 2001, Figure 18).

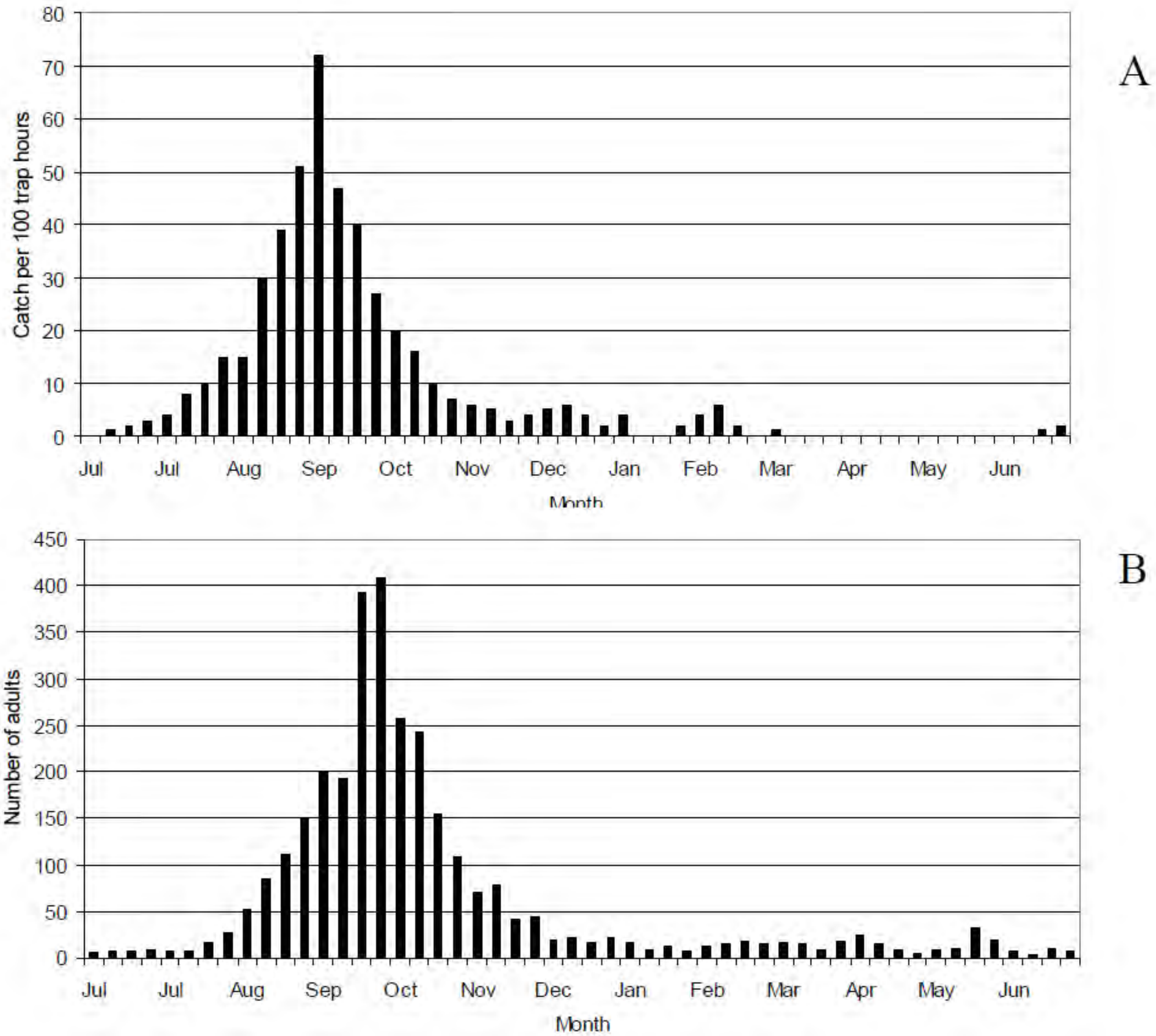


Figure 18: Time pattern of Sacramento River adult steelhead migration. "A" shows the migration timing from July through June of 1953 through 1959, determined by trapping upstream migrants in the Sacramento River just upstream of the confluence with the Feather River (from Hallock *et al.*1961) and "B" shows the weekly average number of adult steelhead counted at RBDD from July through June of 1983 through 1986 (Figures 18A and B from McEwan 2001).

4. Southern DPS of North American Green Sturgeon

Juvenile green sturgeon from the sDPS are routinely collected at the SWP and CVP salvage facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981 through 2014, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. The sizes of these fish are less than 1 m (3.3 ft) and average 330 mm (13.0 inches) with a range of 136 mm to 774 mm (5.35 to 30.5 inches). The size range indicates that these are juvenile fish rather than sub-adult/adult or larval fish. The range of sizes of recovered fish indicate that these juvenile fish utilize the Delta for rearing for up to a period of approximately 3 years before migrating to the ocean and becoming sub-adult fish. The action area is located in close proximity to the main migratory route that juvenile green sturgeon would utilize to enter the Delta from their natal areas upstream on the upper Sacramento River. If the DCC gates are open, there is a direct connection to the Mokelumne River system, and presence of green sturgeon is likely. The fact that juvenile green sturgeon are captured at the CVP and SWP facilities, which are approximately 35 river miles south of the action area, would indicate that green sturgeon are more likely to be present in the action area during the proposed Project, and in higher densities, than are observed at the fish collection facilities. Likewise, since the action area is on the main migratory route utilized by adult green sturgeon to access the spawning grounds in the upper Sacramento River, it is likely that adult green sturgeon will be present in the action area. Adult green sturgeon begin to enter the Sacramento – San Joaquin Delta in late February and early March during the initiation of their upstream spawning run. The peak of adult entrance into the Delta appears to occur in late February through early April, with fish arriving upstream of the Glen-Colusa Irrigation District's water diversion on the upper Sacramento River in April and May to access known spawning areas. During this period, the DCC gates are closed and the majority of adult green sturgeon are expected to remain in the mainstem Sacramento River during their upstream movements. Adults continue to enter the Delta until early summer (June-July) as they move upriver to spawn, at which time the DCC gates are typically open, allowing an alternative migratory route to the upper Sacramento River basin. It is also possible that some adult green sturgeon will be moving back downstream as early as April and May through the action area, either as early post spawners or as unsuccessful spawners. The majority of post spawn adult green sturgeon will move down river to the delta either in the summer or during the fall when the DCC gates are open. Fish that over summer in the upper Sacramento will move downstream when the river water cools and rain events increase the river's flow. When the gates are open, fish may enter the DCC and move into the Mokelumne River system. Acoustically-tagged adult green sturgeon have been detected by receivers placed in the DCC channel, indicating that they have moved through it from the Sacramento River (Battleson and Thomas 2015).

2.3.1.2 Status of Critical Habitat within the Action Area

The PBFs for steelhead and spring-run Chinook salmon habitat within the action area include freshwater rearing habitat and freshwater migration corridors. Estuarine areas occur farther downstream where mixing occurs and salinity is greater than 0.5 parts per thousand (ppt). The features of the PBFs included in these different sites essential to the conservation of the CCV steelhead DPS and CV spring-run Chinook salmon ESU 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 rearing and migration by CCV steelhead and CV spring-run Chinook salmon juveniles and smolts and for adult freshwater migration. No spawning of CCV steelhead or CV spring-run Chinook salmon occurs within the action area.

Critical habitat for winter-run Chinook salmon includes the Sacramento River reach within the action area. Critical habitat elements include the river water, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. Downstream migration of juveniles and upstream migration of adults should not be impeded or blocked. Adequate forage base is required to provide food for emigrating juvenile winter-run.

In regards to the designated critical habitat for the sDPS of North American green sturgeon, the action area includes PBFs which provide: adequate food resources for all life stages utilizing the Delta; water flows sufficient to allow adults, sub-adults, 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 Delta and estuary; and sediment with sufficiently low contaminant burdens to allow for normal physiological and behavioral responses to the environment.

The general condition and function of the aquatic habitat has already been described in the *Rangewide Status of the Species and Critical Habitat* section of this biological 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.

Within the action area, the construction of the DCC in the early 1950s created an artificial channel to supply Sacramento River water to the Mokelumne River system and portions of the central and southern Delta. This artificial channel disturbed the natural flow of water through the eastern, central and southern Delta and created a “fresher water quality” condition within a large segment of the Delta, particularly during low flow conditions.

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon. All juvenile winter-run and spring-run Chinook salmon, the sDPS of North American green sturgeon, as well as those CCV steelhead smolts originating in the Sacramento River basin must pass into and through the northern Delta to reach the lower Delta and the ocean. A large fraction of these fish will likely pass downstream through the action area within the Sacramento River channel. Likewise, adults migrating upstream to spawn are likely to pass through the action area within the main stem of the Sacramento River to reach their upstream spawning areas. Therefore, it is of critical importance to the long-term viability of the Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, the sDPS of North American green sturgeon, and CCV steelhead to maintain a functional migratory corridor and freshwater rearing habitat through the action area.

2.3.1.3 Factors Affecting the Species and Habitat in the Action Area

The action area encompasses a small portion of the area utilized by Sacramento River winter-run and CV spring-run Chinook salmon, and CCV steelhead as well as the sDPS of North American green sturgeon. Many of the factors affecting these species in the action area are considered the same as throughout their range, as discussed in the *Rangewide Status of the Species and Critical Habitat* section of this biological opinion, specifically, levee armoring and channelization, alteration of river flows and timing, reduction of LWD in the waterways, and the introduction of point and non-point contaminants and are incorporated here by reference.

2.4 Effects of the Action

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

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536). This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, and the threatened sDPS of North American green sturgeon and the designated critical habitat for each of these listed anadromous fish species, respectively.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Rangewide Status of the Species and Critical Habitat* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitats that are likely to be adversely affected by the activity under consultation.

NMFS generally approaches the "jeopardy" and critical habitat 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 responses) to those effects to determine if those effects could 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; or decreasing the age at which individuals stop reproducing). 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.

To conduct this assessment, NMFS examined information from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, government and non-government reports, the BA for this project, and supplemental material provided by the applicant in response to questions asked by NMFS.

The proposed Project generally will affect more adult fish than juvenile fish. The larger effects to the adult population, in terms of numbers of adults subjected to Project activities compared to juveniles, will result in greater impact to the population because individual adult fish have a higher contribution to the cohort replacement rate than individual juvenile fish. In particular, adult fish that return to freshwater have survived the risks during their freshwater and ocean residence (*e.g.,* predation, competition, water diversions, *etc.*) that outmigrating juvenile fish have yet to face and adult abundance is considerably lower. For example, Emmett *et al*. (1997) estimated a general juvenile Chinook salmon survival in freshwater to be between 5 and 25 percent and ocean survival to be between 1 and 10 percent. Thus, overall survival of juveniles to adult would range from 0.05 percent to 2.5 percent (5 percent x 1 percent = 0.05 percent, 25 percent x 10 percent = 2.5 percent) and the abundance of juveniles in freshwater needed to maintain a cohort replacement rate of 1.0 with a population level of 10,000 spawners would range between 400,000 and 20 million (10,000/.025 = 400,000, 10,000/0.0005 = 20 million) juveniles. The impacts of the proposed Project on adult abundance could affect the cohort replacement rate by decreasing the contributing adult portion of the population, and ultimately juveniles entering the marine environment to become adults for the next generation. Similarly, because of the high fecundity of North American green sturgeon and the relatively high abundance of juveniles expected in the action area compared to adults, the impacts of the Project on adult green sturgeon also are expected to be more severe than the impacts to juveniles. Loss of adult green sturgeon would have a ripple effect on multiple cohorts of juveniles due to the long life span and repeated spawning events that an adult may participate in, and the loss of that individual adult fish to the production of future cohort progeny.

2.4.1 Assessment

2.4.1.1 Dual-Frequency Identification Sonar (Didson) Camera Systems

Adult and juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon use the action area primarily as a migration corridor (see the *Regionwide Status of the Listed Species and Critical Habitat* and *Environmental Baseline* sections). In-channel placement of the Didson camera units will occur over a 1-week period from approximately October 3 to October 9, 2016. The hydroacoustic system will then be completely removed from the water following the completion of the study, by December 1, 2016. The hydroacoustic system will be lowered into position from a utility boat either by hand or by a winch and boom. There will be no pile driving or other mechanical installation associated with positioning the two devices on the channel bottom other than as described in the project description (Reclamation 2015a). Therefore, noise associated with the installation of the hydroacoustic device is expected to be minimal and be comprised of transient noises that may momentarily spike and then fall back to background levels. The transient spikes of noise are not expected to reach levels that would be sufficient to cause acute or delayed injury to fish in the vicinity of the device placement. Sharp transient spikes of noise are most likely to occur where the metal of the anchoring mount strikes a hard object, such as a rocky outcropping or the rock rip rap of the levee face. Since the substrate along the toe of the levee and outwards from the bank is typically soft sediment, there is little expectation that the anchoring mount will encounter a hard surface from which sharp transient spikes in noise will be produced.

The hydroacoustic array will be mounted on an anchor mount (see Figure 22) which will secure the array in a fixed position on the river channel bottom. Power and signal feed cables will be routed from the anchor mounts to the shore facilities. Each anchor mount will have a dual axis rotator to sweep through a 90 degree arc each hour as the rotator turns back and forth in the horizontal plane of the rotator. The transducer can emit acoustic signals of 75 kilohertz (kHz) or higher. These frequencies are above the threshold of hearing for both salmonids and green sturgeon, and therefore should not be detectable to these fish species. The footprint of the anchoring mount will be approximately 1 m by 1 m (3.3 ft by 3.3 ft) and therefore cover one square meter (m^2) or approximately 10 square feet (ft^2) in area. Since the deployment of the unit is temporary, lasting a maximum of 7 weeks during the October 3 to December 1 2016 study period, there is no permanent impact to the designated critical habitat in Snodgrass Slough or Dead Horse Cut for CCV steelhead and the sDPS of North American green sturgeon. Temporary impacts are anticipated to include disruption of the channel substrate from the anchor mount's points of contact with the bottom, a small physical obstructions to the river's flow creating hydraulic breaks along the bottom, and potential "crushing" of benthic infauna in the channel substrate by the weight of the unit's anchoring mount. These impacts are considered temporary as the anchoring mount will be completely removed at the end of each study season, and the impacted channel bottom allowed to recover. Since the impacted footprint is very small compared the area of the surrounding undisturbed channel bottom [3 m^2 or approximately 30 ft^2 (10 square feet x 3 mounts = 30 ft^2)], the integrity of the designated critical habitat in the action area is not diminished, and the impacted area is expected to be recolonized by benthic invertebrates from the immediate surrounding area. The cumulative area impacted is the 3 m^2 (30 ft^2) of the anchor mounts plus the area covered by cables supplying power to the units and carrying data back to the shore side electronics during each study season for the approximately 7 weeks of deployment.

2.4.1.2 Acoustic Telemetry Receivers

Reclamation plans to deploy acoustic receivers at 7 sites in the action area (Figure 20). Each of the hydrophones will be secured to the channel bottom with the weight of a standard cinder block, which has the dimension of 16 inches by 8 inches by 8 inches. The mounts will be lowered to the channel bottom from a boat, either by hand or with a mounted winch and boom. The surface-oriented hydrophones will be attached to ropes suspended from the anchoring mount by a float and positioned in the upper portion of the water column, but below the water surface (1 meter below the lowest anticipated water surface elevation). The acoustic receivers will be attached to the ropes by zip ties. No additional mechanical equipment is proposed to situate the anchor mounts. Thus any noise associated with the installation should be related to transient spikes and therefore should not produce acoustic noise that would result in acute or long term cumulative injuries to exposed fish during the installation process. Installation of the hydrophones will take place no earlier than October 3 in the 2016 study season and the study will be conducted over a 7-week period. The hydrophones are passive receivers of the acoustic signals present in the water column, which includes the signals emitted by the acoustic tags. The frequency of the tags used in this element of the Project is above the upper threshold for hearing in the fish species of interest and therefore is not expected to affect the fish exposed to the emitted signals from the acoustic tags, either physically or behaviorally.

The placement of the anchoring mounts (7 total anchor mounts for this study element) will temporarily impact the bottom substrate of the Sacramento River channel as well as Snodgrass Slough, Dead Horse Cut, and the North Fork, South Fork, and mainstem of the Mokelumne River. As described in the previous sections describing designated critical habitat for winter-run and spring-run Chinook salmon, CCV steelhead, and the sDPS of North America green sturgeon, the channel bottom substrate is considered essential to the proper functioning of the critical habitat. The placement of the 7 anchor mounts is not likely to substantially alter or degrade the functioning of the impacted substrate. The anchor mounts will rest superficially on the bottom and may crush organisms immediately beneath them. In addition, the anchor mounts, ropes, and surface buoys may serve to attract fish to hold in their vicinity due to hydraulic breaks created by these structures, although relatively small compared to the total area within the action area. The anchor mounts are small, approximately 0.09 m^2 (1 ft^2) in area. The total area impacted by the anchor mounts in this element of the Project is approximately 0.65 m^2 [7 ft^2 (7 anchor mounts x 1 ft^2/ mount = 7 ft^2)]. Since the impacted footprint is very small compared to the area of the surrounding undisturbed channel bottom, the overall impact of the anchor mounts is considered to be inconsequential to the functioning of the critical habitat within the action area. Furthermore, the placement of the hydrophones for this element of the study is temporary, lasting approximately 10 weeks prior to the removal of the anchor mounts at the end of the 2016 study season. The disturbed areas of the channel bottom related to the anchor mounts are expected to be recolonized almost immediately by invertebrates from surrounding undisturbed areas upon removal of the anchor mounts.

2.4.1.3 Fish Collection

One of the consequences of using entrapment gear (*e.g.*, fyke traps) is bycatch. Bycatch is the incidental capture of non-targeted species along with the targeted species in the deployed gear. Non-targeted species may include organisms that are not the intended species of the fishing action, under-sized individuals of the targeted species, or the “wrong” sex (Davis 2002, Stein *et al.* 2004, Gessner and Arndt 2006, Bettoli and Scholten 2006, Bettoli *et al.* 2009, and Uhlman and Broadhurst 2015). This bycatch is typically discarded and returned to the waters in which the fishing gear was deployed. All major fishing gear types involve some degree of injury to the captured fish by internal and external wounding, crushing, scale loss, asphyxiation, and hydrostatic effects in deep waters (barotrauma), with the severity of injury dependent on many variables, including gear type, species, and environmental conditions (Davis 2002, Bettoli and Scholten 2006, Uhlman and Broadhurst 2015). The discarded bycatch frequently has a high mortality rate associated with it unless special precautions are undertaken to minimize the level of mortality. In addition to discarded bycatch, fishing gear frequently has other sources of unwanted mortality associated with it including: 1) ghost fishing of derelict and lost gear, 2) depredation of fish caught in the gear, 3) escaping or dropping out of gear during retrieval, 4) habitat damage, and potentially 5) avoiding gear and predation, and 6) latent mortality from infection of injuries sustained from the above sources.

When several stressors act in unison at the same time, the ability of the organism to compensate for the adverse physiological changes is diminished, resulting in excessive fatigue, stress, and eventual death. Presence of listed fish in the Delta during the period that the fish monitoring study is being conducted (see section 2.3.1.1) will make individuals vulnerable to contact with the fishing gear (Figures 25, 26, 27, and 28) and may result in the bycatch of these listed fish.

2.4.1.3.1 Fyke Traps

The fyke trap is designed as a passive fishing method, which consists of two compartments, and is approximately 20 feet in length, 10 feet in diameter (Reclamation 2016a). The fyke traps are positioned with the open end of the cones facing downstream, so that upmigrating fish swim into the cones and become trapped. Fish behavior typically prevents most fish from exiting back through the smaller mouth of the conical section of the trap. A second conical section leads to a live box or fish trap at the end of the structure where the fish are retained until the fyke trap is emptied. The traps will not span the entire width of the river channels where they are deployed, to allow boat traffic and aquatic organisms to pass by unimpeded in the river sections unoccupied by the traps. The traps will be deployed with boat crew or from shore. Each trap will be secured with the installation of less than ten 6-8 ft. t-posts in the embankment slope. The traps will be inspected at least once daily. Traps are retrieved from their sampling position by attaching a guideline from a winch to a main line wrapped around the trap. The process of reeling in the trap with the winch is aided by additional guidelines wrapped around the front and back of the trap, controlled by crew on the shoreline. The trap will positioned in a water depth that provides enough water for trapped fish. Three swinging doors on each trap allow access to remove fish using large dip-nets.

Once fish are retained within the fyke trap, there is potential for injury or mortality to entrapped fish. If fish density is too great, local dissolved oxygen content of the water may decline due to the respiration of numerous fish within a confined area. This is exacerbated by warm ambient water temperatures that hold less oxygen to begin with. In addition, close confinement of numerous species of fish with a range of fish sizes may lead to predation of some smaller fish by larger predators within the net confines. Environmental conditions such as warm ambient water and low dissolved oxygen will also influence survival rates both in the trap and after release. In a study looking at immediate and long term survival of Atlantic salmon (*Salmo salar*) in the Baltic Sea captured by commercial salmon net traps, tagged salmon showed high levels of survival, even after repeated captures during their spawning migration. The mean maximum capture and release induced mortality of salmon was 11 percent, ranging between 4 percent and 21 percent in different release groups by year, sea age, and number of releases from trapping gear (Siira *et al*. 2006). Reclamation scientist conducting fyke net trapping on fall-run Chinook salmon have had a mortality rate of less than 1 percent operating on the San Joaquin River (Reclamation 2015a). In studies conducted in 2012 and 2013, 485 individual fish were caught with only 3 mortalities observed in the net. Reclamation indicates that some of these mortalities may have been due to the advanced stage of pre-spawning conditions in these fish, and not to the nets themselves.

Water temperature plays an important role in the mortality of captured fish (Uhlman and Broadhurst 2015). As water temperature increases, the physiological capacity of the captured fish to withstand the multiple stressors associated with capture is reduced – the fish is less resilient to the process of capture and may die as a result. Cooler waters reduce the stress level and enhance survival through better oxygen uptake and more favorable metabolic conditions, allowing better survival in the net and quicker recovery post release. Warmer water has lower dissolved oxygen content that leads to more hypoxia in trapped fish struggling against the net's entanglement. Studies in white sturgeon (Cech and Crocker 2002) demonstrated reduced swimming ability in hypoxic conditions that could negatively affect post release survival. During the proposed period of the fish monitoring study, ambient water temperatures in the Mokelumne River system are frequently above 20°C (68°F) and may exceed 23°C (73.4°F) for periods of time in early September (Figures 29 and 30). Water temperatures typically drop below 20°C towards the end of September. The health and survival of captured fish is expected to improve substantially when ambient water temperatures fall below 20°C, indicating that the study period after the last week of September will have better survival than the portions of the study conducted in the beginning of September. Kahn and Mohead (2010) stated that increasing water temperature, decreasing DO, and increasing salinity were detrimental to sturgeon and resulted in lower survival of fish. In studies using green sturgeon (northern Distinct Population Segment of North American green sturgeon), optimal growth for juvenile fish was shown to occur at water temperatures between 15° and 19°C, and reduced growth rates between 20° and 24°C (see Table 9 and references cited within). Survival of salmonids is expected to be less than green sturgeon at the warmer temperatures (above 20°C) but will become more comparable as water temperatures cool below 20°C. Temperature preferences and physiological responses for Chinook salmon and steelhead respond in a positive manner to water temperatures that become cooler than 20°C (68°F). Water temperatures above 20°C are stressful to salmonids in general, leading to depressed physiological function, oxygen utilization, and disease resistance (US EPA 2003). As water temperature increases, exceeding 20°C, the additional stress of capture will lead to increased incidence of mortality (Uhlman and Broadhurst 2015) from the combined effects of capture and thermal stress.

Fish traps, such as fyke traps and nets, are subject to seal attack and predation of the fish inside of them. Raby *et al*. (2014) discusses the underestimated role of predation on overall survival of fish that encounter nets, while Lehtonen and Suuronen (2010) discuss the specific interactions of gray seals (*Halichoerus grypus*) with pontoon-style fish traps in the Baltic Sea that are similar in several design elements to fyke nets. Gray seals have learned how to enter the trap through the conical sections in the middle chamber and feed on the Atlantic salmon confined to the final fish chamber. Lehtonen and Suuronen (2010) report that all of the seals in their study captured in the fish traps were male and typically visited the traps at dawn or dusk. Several of the seals were observed via underwater cameras visiting the traps numerous times before being captured, indicating that this behavior was learned and not random.

Freshwater and marine mammals are known to occur in the action area. Predators such as river otters (*Lutra canadensis*), and pinnipeds, including harbor seals and California sea lions occur in the Delta waterways. River otters are endemic to the Delta and are known to be capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993). Although harbor seal and sea lion predation primarily is confined to the marine and estuarine environments, they are known to travel well into freshwater after migrating fish and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin rivers. All of these predators are opportunists, searching out locations where juvenile and adult fish are most vulnerable, such as the large water diversions in the South Delta or where fish are captured in fishing gear such as nets. Predators can remove fish from the mesh of the nets after they are caught (depredation mortality), chase fish that are obstructed by the net deployment (predation mortality) from their normal movements, or are captured by predators after they are discarded from the fishing operation as discarded bycatch (predation mortality) (Raby *et al*. 2014, Uhlmann and Broadhurst 2015). Stress and injury from the process of being captured and either escaping or being returned to the water as discarded bycatch can temporarily impair physiological capacity and alter behavioral responses to predators in released animals, a period during which predation risk is likely elevated (Raby *et al*. 2014). Predators are attracted to the areas where “easy” prey is available. The project will incorporate the use of marine mammal excluders on the fishing gear for the 2016 study season. During the 2015 study period, only two California sea lions were observed within 0.25 miles of the fyke nets. With the use of mammal exclusion devices on the fyke traps and the low occurrence of California sea lions in the area, Reclamation does not anticipate sea lions interfering with or being affected by the Project.

2.4.1.4 Exposure Risk to Listed Species during deployment of the Didson Units, Acoustic Receivers, and Fyke-Traps

The deployment of the fyke traps in the waters of the Delta has the potential to adversely affect listed species in the Delta. As described in section *2.3 Environmental Baseline,* the presence of both juvenile and adult listed fish is likely to occur during the period October 3 to December 1, 2016 (study season 2016).

1. <u>Sacramento River winter-run Chinook salmon</u>

No adult winter-run Chinook salmon are expected to migrate through the Delta during study 2016 season (October 3 through December 1, 2016), and thus, there is no risk associated with the deployment of the fishing gear to adult winter-run Chinook salmon. However, based on the Knights Landing RST data from 2001 to 2012, an average of 10.7 percent of the annual cumulative winter-run juvenile catch occurs by the end of November (0 percent in September, 4.23 percent in October, and 10.7 percent by the end of November; Table 17). The presence of juvenile winter-run Chinook salmon in the Knights Landing RST and Sacramento River trawl is linked to increases in precipitation in the upper Sacramento River basin that results in increases in river flows in the tributaries and mainstem of the Sacramento from Keswick Dam to the Delta.

Fish move downstream when they are physiologically ready to move or are displaced by high flows.

To generate a rough approximation of the proportion of the population exposed to the fishing gear (fyke traps), we must make several assumptions as to the distribution of the fish and their behavior in the waterways surrounding Dead Horse Island. We assume that the cumulative catch percentile for the Knights Landing RSTs serves as a proxy for the percent of winter-run population moving past this location. Then we assume that 25 percent of the natural flow in the Sacramento River goes into the DCC when the gates are open, and that fish move in the same proportion as the water flow (25 percent), then the percentage of the cumulative population of juvenile winter-run that enter monthly is equal to:

> 0.25 (percentage of Sacramento River flow entering the DCC) ∗ (monthly cumulative percentage of fish caught at Knights landing) = percentage of winter-run juvenile population exposed to fishing gear.

We assume that all winter-run entering the DCC when the gates are open will be exposed to the deployed traps at least once. This is due to the DCC splitting into two channels, Snodgrass Slough and Dead Horse Cut, which bound Dead Horse Island on the western and eastern shores. One fyke trap is located in the North Fork Mokelumne River, one in the South Fork Mokelumne River, and one in Dead Horse Cut (Figure 20). Dead Horse Cut empties into the North Fork of the Mokelumne River and fish within this channel can move downstream either within the North Fork or the South Fork of the Mokelumne River. We do not account for any holding or tidal movement behavior for this analysis, which could expose the fish multiple times to the sampling gear during their downstream migration and increase the risk of injury or mortality.

For September the average exposure is:

> 0.25 x 0% = 0% of the winter-run population (no fish pass Knights Landing and none are detected in the RSTs.

For October, the average exposure is:

> 0.25 x 4.23% = 1.06% of the population passing Knights Landing

For November, the average exposure is:

> 0.25 x 3.235% = 0.81%

The value for November is derived from the difference in the values of the monthly cumulative RST values for the end of October and the end of November (10.7% - 4.23% = 6.47%) times 0.5 to account for only the first 2 weeks of the month of November. Thus, a rough estimate of the percentage of winter-run juveniles that may be exposed to the sampling gear from September through mid-November is 1.9 percent of the annual population passing Knights Landing.

2. CV Spring-run Chinook salmon

Adult CV spring-run Chinook salmon are likely to be present in the Delta in September (≈15 percent of annual spawning migration) but not in October or November based on data from the RBDD fish ladders (Table 12). There is the potential to capture adult CV spring-run Chinook salmon during the deployment of fyke traps in early September and misidentify them due to their similarity in appearance to adult fall-run Chinook salmon. Based on data from the Knights Landing and Northern Delta fish monitoring efforts, less than 1 percent of the annual cumulative catch of juvenile CV spring-run Chinook salmon are expected to pass downstream into the Delta during the proposed study period (0 percent in September, 0.07 percent in October, and 0.54 percent in November; Table 18). As indicated previously for winter-run juveniles, precipitation driven flow events will create conditions in which yearling CV spring-run Chinook salmon will emigrate downstream into the Delta. Using the same assumptions and procedure described above for winter-run juveniles, we estimate that the following percentiles of the juvenile and yearling spring-run Chinook salmon population will be exposed to the fyke traps:

For September the average exposure is:

> 0.25 x 0% = 0% of the spring-run population (no fish pass Knights Landing and none are detected in the RSTs.

For October, the average exposure is:

> 0.25 x 0.07% = 0.02% of the population passing Knights Landing

For November, the average exposure is:

> 0.25 x 0.27% = 0.07%

Thus, a rough estimate of the percentage of spring-run juveniles and yearlings that may be exposed to the fyke traps from September through mid-November is 0.09 percent of the annual population passing Knights Landing.

3. CCV steelhead

Based on the information provided in Figure 18, approximately 70 percent of the adult CCV steelhead spawning population in the upper Sacramento River basin moves past the Knights Landing area (just upstream of the Feather River confluence) during the period from September through November). Approximately 50 percent of the population moves through during September and October. During the same period of time (September through November) approximately 2 percent of the juvenile steelhead population moves downstream into the Delta based on Knights Landing and Northern Delta fish monitoring data (Table 11). Adult steelhead are expected to move into the Mokelumne River basin from the Delta, in a similar fashion based on the patterns seen on the Sacramento River. Steelhead juveniles in the Mokelumne River are primarily hatchery origin and are released in January and February, so no juvenile CCV steelhead are expected to be present during the study periods originating from the Mokelumne

River system. Therefore a rough estimate of the number of juvenile steelhead (mostly wild, but potentially some residual hatchery steelhead) that would be exposed to the fyke traps is 0.5 percent of the annual population passing Knights Landing (2% * 0.25 = 0.5%).

4. sDPS of North American Green Sturgeon

Adult sDPS green sturgeon are known to enter the DCC when the gates are open. In 2015, 2 of the 3 fish that migrated downriver to the Delta by the early part of July were detected by acoustic receivers in the DCC (Thomas 2015). Future downloads of receivers will be able to track the movements of these fish through the Delta receiver array. Juvenile green sturgeon are also assumed to be present as they can move through the DCC when the gates are open and are potentially rearing in the Mokelumne River system and Delta for 1 to 3 years prior to leaving for the marine environment to mature into sub-adults. Due to the lack of specific sDPS green sturgeon migratory behavior and movement timing, NMFS cannot estimate the percentage of the population that will be present in the action area during the proposed Project.

In summary, these estimated values represent the percentages of the winter-run, CV spring-run, and CCV steelhead populations moving into the Delta from the upper Sacramento or the numbers moving from the Delta into the Sacramento River based on fishery monitoring data. Estimates for sDPS green sturgeon cannot be made due to a lack of data. The monitoring data are not exact and have considerable noise associated with them. The fraction of the population that moves through the DCC and into the Mokelumne River is also difficult to estimate, but we have assumed that for juveniles it is proportional to the flow split, which is roughly 25 percent. The movement of fish is dependent on river flow splits, position of fish in the Sacramento River channel relative to the opening of the DCC, and on tidal phases. The numbers presented should be viewed as rough estimates of when fish are present and the approximate magnitude of the population at risk, not as exact estimates of the population fractions.

2.4.1.5 Effects to Designated Critical Habitat related to the Deployment of the Didson Units, Acoustic Receivers, and Fyke-Traps

Designated critical habitat for CCV steelhead and sDPS of North American green sturgeon occurs in the waterways in which the fyke traps will be deployed and has been identified as having fresh water rearing and freshwater migratory PBFs for CCV steelhead and food resources, substrate type or size, water quality, water flow, migratory corridor, water depth, and sediment quality PBFs for freshwater riverine systems for sDPS of North American green sturgeon. There is minimal contact with the underlying substrate for the fyke trap while removing captured fish once per day, and traps will be temporarily deployed during the October 3 to December 1 study period before being retrieved. The traps have no impacts to the PBFs for the sDPS of North American green sturgeon related to physical or biotic criteria except as a migratory corridor. The presence of the fyke trap will impede free migration through the deployment areas and is considered a transitory diminishment of the PBFs of freshwater migratory corridors for these two listed species for both adult and juvenile life stages. Since the areas of trap deployments are outside of the areas designated as critical habitat for either winter-run Chinook salmon or spring-run Chinook salmon, there is no impacts related to the deployment of the fishing gear.

2.5 Cumulative Effects

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

2.5.1 Agricultural Practices

Agricultural practices in the Delta may negatively affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. The Delta islands surrounding the action area are primarily agricultural lands with orchards, row crops, and grazing lands for dairy cattle present. The Cosumnes River floodplain is immediately upstream of the action area, and portions of this floodplain are under cultivation for various crops. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids and juvenile green sturgeon and are present in the action area within the mainstem Sacramento River, Snodgrass Slough, Dead Horse Cut, and the Mokelumne River channels. 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 nitrites, nitrates, 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 negatively affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

2.5.2 Increased Urbanization

The action area occurs within the Delta and Sacramento regions, which include portions of Sacramento, Solano, and Yolo counties. Population is expected to increase by nearly 3 million people by the year 2020 in the Delta region. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the cities of Elk Grove, Laguna, Galt, and West Sacramento are anticipated to experience rapid growth for several decades to come and are located within a 25-mile radius upstream of the action area on the Sacramento River and the Cosumnes River. These waterways are either directly connected to the action area (Sacramento River) or are a tributary to the Mokelumne River, which flows through the action area. The anticipated growth will occur along both the I-5 and US-99 transit corridors. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation processes with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. There are currently 10 boating facilities (private and public docks and marinas) within the immediate vicinity of the action area that would draw boaters to the area. In addition, the DCC is a main access point for boaters travelling between the Sacramento River and the interior Delta and is heavily utilized by recreational boaters. Any increase in recreational boating due to population growth would likely result in increased boat traffic in the action area. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially 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. Furthermore, increased recreational boating, particularly those that can be trailered from one water body to another, greatly increases the risk of spreading non-native invasive species into the Delta.

2.5.3 Global Climate Change

In section 2.2.5, NMFS discussed the potential effects of global climate change. Anthropogenic activities, most of which are not regulated or poorly regulated, will lead to increased emissions of greenhouse gasses. It is unlikely that NMFS will be involved in any review of these actions through an ESA section 7 consultation. Within the context of the brief period over which the proposed project is scheduled to be operated (September 1 to November 13 for 2015 study season and October 3 to December 1 for 2016 study season), the near term effects of global climate change are unlikely to result in any perceptible declines to the overall health or distribution of the listed populations of anadromous fish within the action area that are the subject of this consultation.

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.

2.6.1 Summary of Current Conditions and Environmental Baseline

The *Rangewide Status of Species and Critical Habitat* and *Environmental Baseline* sections show that past and present impacts to the Sacramento and San Joaquin river basins and the Delta have caused significant salmonid and green sturgeon habitat loss, fragmentation and degradation throughout the historical and occupied areas for these species. These impacts have created the conditions that have led to substantial declines in the abundance and long term viability of the winter-run and CV spring-run Chinook salmon, the CCV steelhead, and the sDPS of North American green sturgeon. As a result of the current conditions and status of the species, NMFS has determined in its most recent 5-year review (2011) that the listings for endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, and threatened CCV steelhead (NMFS 2011a, b, c, respectively) are still warranted, and that the current status of these fish has declined since the previous 5-year review in 2005. The most recent 5-year review for sDPS of North American green sturgeon found that the status of the species has not changed since its original listing in 2006, with many of the threats cited in the original listing still present. Threatened status for the sDPS of North American green sturgeon is still warranted (NMFS 2015b).

Alterations in the geometry of the Delta channels, removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by demands of water diverters (including pre-1914 riparian water right holders, CVP and SWP contractors, and municipal entities), and the influx of contaminants from agricultural and urban dischargers have substantially reduced the functionality of the aquatic habitat within the occupied areas of the Delta for winter-run and CV spring-run Chinook salmon, CCV steelhead, and sDPS of North American green sturgeon. This includes the waterways contained within the action area.

The current multi-year drought in the Central Valley of California has adversely impacted the populations of winter-run and CV spring-run Chinook salmon and CCV steelhead in the Central Valley, exacerbating the conditions that led to the species being listed. Lethal water temperatures in the tailwaters below the rim dams have reduced the viability of eggs in the gravel for winter-run and spring-run, and have made tributaries excessively warm over the summer and fall seasons due to a lack of snow and snow melt runoff. In 2014, the incubating eggs of the winter-run Chinook salmon population below Keswick Dam were exposed to high water temperatures during the later part of their development, and mortality was estimated at 95 percent for eggs and fry prior to reaching RBDD. Early life stages of sDPS of North American green sturgeon are expected to be less affected by the increased temperatures in the waters in which they spawn due to their higher thermal tolerances in the early life stages compared to salmonids.

2.6.2 Summary of Effects of the Proposed Action

The proposed action will occur over a 2-month period during the 2016 study season: October 3 through December 1, 2016. The effects will be temporary since the fyke-traps, Didson units, and acoustic hydrophone receivers will be completely removed immediately upon completion of the 2016 study season.

The proposed Project will result in adverse effects on Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS of North American green sturgeon. NMFS expects that take will occur in the form of pursuit, capture, harm, and injury, including the potential for death, as a result of stress or injury in fyke-traps. However, these effects are expected to be minor in scope in relation to the species' respective populations, affecting a limited number of fish over the short duration of the study. NMFS expects that there will not be any discernable permanent negative effects to designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS of North American green sturgeon related to the implementation of the Project that would compromise or preclude the functioning of PBFs in the action area.

2.6.3 Sacramento River Winter-Run Chinook salmon

A small proportion of the adult winter-run population may be present in the Delta during the end of the Project, and thus may be exposed to the activity. The placement, operation, or retrieval of the acoustic equipment is not expected to have any adverse effects upon any adult winter-run Chinook salmon within the action area. As described above, the operations of the Didson camera units produces sound at frequencies above the hearing bandwidth of salmonids. Thus, the operation of this hydroacoustic equipment is not expected to have any impact on salmonids that move within the ensonified field projected by the sonar. The acoustic hydrophone receivers are passive and only detect the pings of the acoustic tags placed in the study fish and do not emit any sound themselves. Retrieval of the acoustic receivers and Didson cameras may cause transient noise as they are lifted from the channel bottom into the work boats, but the intensity and duration of any sounds produced are not expected to be of sufficient magnitude to cause harm or behavioral modifications to any fish in the vicinity.

Fyke traps will be deployed once the acoustic hydrophones and Didson camera units are in place, which will be in early October 2016. Fishing ends sometime in November, and all equipment will be removed from the water by December 1, 2016. During the 2016 study period of October 3 through December 1, a small proportion of adult winter-run Chinook salmon are expected to be present in the action area waterways. This is based on the timing of adult winter-run entrance into the Delta during their upstream spawning migration. Adult fish are not expected to start entering the Delta until late November or early December at the earliest. There is a low risk of entanglement or entrapment to adult winter-run Chinook, as part of the population begins to migrate through the Delta by the time the fishing gear is removed on December 1. For those adult fish that do encounter the fyke traps, there will be potential adverse effects, including delays in migration due to entrapment, injury, mortality, or latent mortality after the fish is released. All listed fish are to be released as quickly as possible (< 10 minutes) if they are in "good shape." If any of these captured fish show signs of distress or are injured or bleeding, they will be placed in aerated recovery nets or containers until their condition improves to the point that they can maintain position, are active, and ventilating normally. When these conditions are satisfied, they will be returned to the river. This form of post-capture resuscitation has been shown to dramatically improve post-capture survival in salmonids (Farrell *et al*. 2001).

NMFS has estimated that approximately 1.9 percent of the annual population of juvenile winter-run moving past Knights Landing may be exposed to the effects of the fish traps in the action area. Vulnerability of fish to the fishing gear will be dependent on fish movements in the area of gear deployment. It is likely that less than the entire 1.9 percent of the population would enter the DCC and be exposed to the traps due to the size of the trap in comparison with the channel.

Juvenile winter-run encountering the traps in October or early November will have the benefit of cooler water conditions in the Delta, which will reduce the stress of entrapment compared to the water temperatures present a month earlier in last year's study. As previously described, the water temperatures in the North and South Forks of the Mokelumne River during the study period are typically over 20°C through the month of September (Figures 29 and 30). By the time juvenile winter-run could be present in the action area (early October), water temperatures have typically dropped below 20°C and will be approximately 15°C by the end of October. The cooler water temperatures are expected to reduce immediate stress of fish caught in the fyke traps in, as well as reduce latent mortality after the winter-run bycatch is released back into the river.

Juvenile fish are less likely to be captured than adults since they travel downstream during their outmigration and the fyke traps are oriented with the openings facing upstream to capture adults upmigrating towards their spawning grounds.

The fyke trap will be checked daily for captured fish and targeted fish processed while non-targeted fish are released. More frequent assessment of the number of fish in the fish chamber of the fyke traps can be used to identify potential predation risks to smaller fish such as juvenile winter-run Chinook salmon in the presence of larger predators such as striped bass, black bass (*Centrarchidae*), pike minnows, or catfish (*Ictaluridae*).

2.6.4 Central Valley Spring-Run Chinook Salmon

No adult spring-run Chinook salmon are expected to be in the waters of the action area during the scheduled field placement of acoustic receivers, Didson camera units, and fyke traps in early October, and their removal by December 1. Based on historical monitoring records at RBDD, approximately 15 percent of the adult spring-run Chinook salmon population is expected to be present in the Delta waterways as late as early September. After mid-September, adult spring-run are not expected to be in the Delta system. There is no risk of entrapment to adult spring-run Chinook, as all of the population will have moved through the Delta by the time the gear is starting to be deployed in early October. Therefore, deployment of these instruments will not impact adult spring-run Chinook salmon.

Using the same data from the Knights Landing RST monitoring efforts, juvenile spring-run may be present in low numbers in the Delta starting in October. Based on the data, approximately 0.07 percent of the average annual cumulative catch of spring-run Chinook salmon in the Knights Landing RSTs will be caught by the end of October. By the end of November the average cumulative percentage of the population caught in the RSTs rises to 0.54 percent (Tables 15 and 18). The population of spring-run detected in the RSTs is a mixture of YOY juveniles and older yearlings. Like the winter-run juveniles discussed above, movement of these fish is also influenced by precipitation events upstream of the Delta in the Sacramento River basin. Therefore the percentage of the annual population caught during the early periods of the migration season will be variable and dependent on weather events producing precipitation. The main period of emigration of spring-run Chinook salmon into the Delta occurs later in the season, centering on February through April. Therefore, based on the information available, there is a low level of risk of entrapment of juvenile spring-run in fishing gear deployed.

However, due to the variability of the precipitation events and their stimulus to early downstream migration to the Delta, an exact risk to the population cannot be calculated. NMFS has estimated that approximately 0.09 percent of the juvenile spring-run population moving annually downstream past Knights Landing has the potential to be exposed to the traps in the action area. The fyke traps will impede a portion of the migration in the waterways of Dead Horse Cut and the North and South Forks of the Mokelumne River. The traps will not block the entire waterway, thus allowing the passage of fish in areas not occupied by the trap.

Juvenile spring-run Chinook entering the Delta in October or November during the study period will encounter cooler water than in September. The beneficial aspects of this have already been described for juvenile winter-run in section 2.6.3.

Juvenile spring-run Chinook salmon will experience the same factors regarding the fyke traps as has already been described for juvenile winter-run Chinook salmon. The YOY spring-run have the potential to pass through the 2-inch (5.1 cm) mesh based on their size, and thus less likely to incur injury and mortality due to entrapment than larger fish. Conversely, the larger yearling sized spring-run Chinook salmon may be more susceptible to entrapment, and thus incur more injuries than the smaller juvenile winter-run Chinook salmon.

2.6.5 California Central Valley Steelhead

Both adult and juvenile CCV steelhead will be present in the Delta during the initial deployment of the acoustic receivers and the Didson camera equipment and its retrieval at the end of the study. For the same reasons previously explained, the placement, operation, or retrieval of the equipment will not likely have any adverse effects upon any CCV steelhead within the action area.

Approximately 70 percent of the annual spawning adult steelhead population in the Sacramento River basin moves upriver into the Sacramento River above the Feather River from September to November, based on the figures from McEwan (2001). During the same time, adult steelhead are likely staging in the Delta to move into other watersheds such as the Feather, American, and Mokelumne rivers to spawn in those watersheds. Although the average size of CCV steelhead is typically smaller than adult Chinook salmon, the two fish species are expected to have similar vulnerabilities to entrapment in the fishing gear employed in this study. The small size of the mesh in fyke traps [2-inch stretched (5.1 cm)] will entrap all adult steelhead that attempt to pass through.

For those adult fish that do encounter the fyke traps, there will be potential adverse effects, including delays in migration due to entrapment, injury, mortality, or latent mortality after the fish is released. After the beginning of October, water temperatures typically fall below 20°C and survival will improve as the water temperatures continue to cool through November. Adult steelhead will not be entrapped for more than a 24-hour period in the rigid fyke trap. All listed fish are to be released as quickly as possible (< 10 minutes) if they are in “good shape.” If any of these captured fish show signs of distress or are injured or bleeding they will be placed in aerated recovery nets or containers until their condition improves to the point that they can maintain position, are active, and ventilating normally. When these conditions are satisfied, they will be returned to the river. This form of post-capture resuscitation has been shown to dramatically improve post-capture survival in salmonids (Farrell *et al*. 2001). The mesh wall will act as a behavioral and physical deterrent to fish, thus preventing fish from trying to pass through it once inside the fyke trap. It is unclear whether steelhead smolts will attempt to pass through the 2-inch (5.1 cm) mesh openings.

Approximately 2 percent of the annual juvenile steelhead smolt population sampled in the northern Delta fish monitoring programs are caught in September and through mid-November. Movement of these steelhead smolts may be connected to increases of tributary flows from precipitation events, but patterns of movement, as indicated by the monitoring catches, are much more variable than for Chinook salmon. Note that steelhead smolts and juveniles are inefficiently sampled by trawls and RSTs and can actively avoid these capture methods, particularly in clear water conditions. However, NMFS used those data to estimate that of the 2 percent of the annual downstream emigrating population of steelhead smolts that are expected to enter the Delta during the September through mid-November time frame, approximately 0.5 percent will enter the DCC when the gates are open and encounter the traps.

2.6.6 Southern DPS Green Sturgeon

Since juvenile green sturgeon are expected to be rearing in the waterways of the Delta, including the action area, on a year-round basis, they are expected to be in the vicinity of the acoustic receivers and the Didson camera equipment during their deployment, operation, and retrieval. Likewise, juvenile green sturgeon are going to be present during the 2 months the traps are deployed in the action area during the 2016 study season. Currently, there is not a reliable measure of juvenile green sturgeon population abundance in the Delta, nor is there a reliable estimate of the relative fraction of the population utilizing the action area during implementation of the Project. Therefore, juvenile green sturgeon presence is assumed to occur during these periods without knowing the actual proportion of the population this comprises. Likewise, adult green sturgeon are likely to be migrating downstream during installation and removal of the acoustic receivers and Didson camera units, as well as the deployment of the fyke traps in the action area.

As discussed above in sections 2.4.1.1 and 2.4.1.2, the deployment, retrieval and operation of both the acoustic receivers and Didson camera units are not expected to adversely affect either adult or juvenile green sturgeon in the action area. The transient noise spikes produced during the deployment of the acoustic receivers and Didson camera units are not likely to produce sound exposures that would cause injury or death to exposed sDPS green sturgeon due to their duration and magnitude. The operations of the Didson camera units produce sounds at frequencies above the hearing bandwidth of sDPS green sturgeons. Thus, the operation of the hydroacoustic equipment is not expected to have any impact on sDPS green sturgeons that move within the ensonified field projected by the sonar. The acoustic hydrophone receivers are passive and only detect the pings of the acoustic tags placed in the study fish and do not emit any sound themselves. Retrieval of the acoustic receivers and hydroacoustic Didson cameras may cause transient noise as they are lifted from the channel bottom into the work boats, but the intensity and duration of any sounds produced are not expected to be of sufficient magnitude to cause harm or behavioral modifications to any fish in the vicinity.

Both adult and green sturgeon will be exposed to the fyke trap gear. Sturgeon behaviorally start to roll when they encounter nets and, thus, sturgeon are likely to exacerbate their tendency to become injured. If a listed fish is collected in a fyke trap, they are to be released as quickly as possible if they are in "good shape." If any of these captured fish show signs of distress or are injured or bleeding they will be placed in aerated recovery nets or containers until their condition improves to the point that they can maintain position, are active, and ventilating normally. When these conditions are satisfied, they will be returned to the river. This form of post-capture resuscitation has been shown to dramatically improve post-capture survival in salmonids (Farrell *et al.* 2001) and is likely to benefit sturgeon as well. Reclamation has specifically included a recovery net pen that is 7 feet in length that will accommodate large sturgeon if captured. The fyke nets also will be monitored continuously and checked initially every hour for fish. Constant attendance of the net, rapid response to fish entanglement in the net and quick releases, and the availability of recovery nets and containers should minimize the risks to adult and juvenile green sturgeon captured in the fyke traps.

Depredation of sturgeon caught in traps and predation of released sturgeon by seals is a known factor of mortality in the Delta region (Gingras 2015). The risk of predation by marine mammals, such as seals, is reduced or eliminated with the placement of a mammal excluder cross bar on the opening of each fyke trap, and with the recovery net pens prior to release.

2.6.7 Effects of the Project upon Designated Critical Habitats

The proposed Project should have minimal effects on the designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon. Within the action area, the relevant PBFs of the designated critical habitat for listed salmonids are migratory corridors and rearing habitat, and for green sturgeon, the six PBFs include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. The project is unlikely to demonstrably affect rearing habitat or food resources or their availability or any of the water quality, water depth, sediment quality, or hydrology characteristics described in the PBFs. It will have minimal, transitory effects on the functioning of the critical habitat as a migratory corridor during the deployment of the fyke traps, impeding migration in the waterways of Dead Horse Cut and the North and South Forks of the Mokelumne River. The traps will be deployed for a temporary time period, and will not block the entire waterway, thus allowing the passage of fish in areas not occupied by the trap. Captured fish will be allowed to continue on their normal migratory movements as soon as released. When water temperatures reach 22.5^{o}C, sampling will cease until temperatures decrease below 22.5 ^{o}C. Delay in migratory movements due to being captured in the fyke traps will be no more than 24 hours throughout the duration of the study.

The cumulative footprint of the anchor mounts for the Didson camera units is approximately 3.7 m^2 (40 ft^2) and will be in place for 2 months in the 2016 study season. All 4 anchor mounts for the Didson camera systems (2 in Snodgrass Slough and 2 in Dead Horse Cut) are in the designated critical habitat for CCV steelhead and the sDPS of North American green sturgeon. The cumulative footprint for the 7 acoustic receiver anchors is approximately 0.65 m^2 (7 ft^2) and will be in place for the 2-month study season. All 7 acoustic receiver anchors are in the designated critical habitat for CCV steelhead and the sDPS of North American green sturgeon. Only receiver A7 (Figure 20, Sacramento River downstream of the DCC junction) is within the designated critical habitat for winter-run Chinook salmon and for Central Valley spring-run. The overall footprint is approximately 4.6 m^2 (50 ft^2) of impacted benthic substrate. There will be temporary effects to this area of benthic substrate, but it will have negligible effects on the functioning of the designated critical habitat and will be transitory due to the temporary nature of the deployment of the acoustic equipment (2 months for the 2016 study season). The level of impact associated with the anchor mounts for the acoustic receivers and hydroacoustic Didson units will not result in permanent adverse effects or loss of designated critical habitat in the action area.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon.

NMFS has concluded that the Project will not adversely modify or destroy designated critical habitat for:

- California Central Valley steelhead
- sDPS of North American green sturgeon

NMFS has also determined that the Project is not likely to adversely affect the designated critical habitats of Sacramento winter-run Chinook salmon or Central Valley spring-run Chinook salmon.

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 (ITS).

The measures described below are non-discretionary and must be undertaken by Reclamation so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered in this ITS. If Reclamation: (1) fails to assume and implement the terms and conditions of the ITS; and/or (2) fails to require the agents of Reclamation to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation and Reclamation's agents or permittees must report the progress of the action and its impact on the species to NMFS as specified in this ITS (50 CFR §402.14[i][3]).

2.8.1 Amount or Extent of Take

NMFS anticipates that the proposed action will result in the incidental take of individual Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon. Incidental take associated with this action is expected to be in the form of mortality, harm, trap, catch, collect, pursue, wound, or harassment of juvenile Sacramento River winter-run Chinook salmon, adult and juvenile Central Valley spring-run Chinook salmon, adult and juvenile California Central Valley steelhead, and adult and juveniles from the sDPS of North American green sturgeon, resulting from: (1) the deployment and operations of fyke traps during the study seasons from October 3 to December 1, 2016, due to the entrapment of fish in these fishing traps in the waters of the action area; (2) increased vulnerability to predation during the operations of the fishing traps; and (3) the impedance of free migratory movements within the channels of Snodgrass Slough, Dead Horse Cut, and the North and South Forks of the Mokelumne River during the operational periods of the DCC fall-run Chinook salmon Monitoring Project.

The number of listed fish captured in the traps, the number of observed mortalities in the traps, the number of fish moribund or injured that must be resuscitated prior to release, and the number of mortalities observed during resuscitation attempts will provide the basis for determining a quantifiable metric of incidental take of listed fish. The following provides the incidental take limit for each species, by life history stage.

- All listed fish that are captured in the fyke traps will be considered as part of the incidental take of the Project. These fish would have been trapped and caught, and therefore part of the take associated with the Project, but are incidental to the purpose of the Project and can be quantified.

- Fish that are captured in the fyke traps and released either immediately or after successful resuscitation will be considered as non-lethal take. Fish that are found dead in the traps, alive but with obvious injuries of a serious nature in the traps (*i.e.*, deep lacerations, damaged gills, profuse bleeding, *etc.*), or die during resuscitation attempts will be considered as lethal take. Total take, which includes both non-lethal and lethal take, shall be limited to the following:

  - No more than 250 juvenile Chinook salmon of either the winter-run or spring-run length-at-date classifications shall be captured throughout the study season. Run designation is determined by length-at-date run designations using the river model.
  - No more than 250 CCV steelhead smolts (unclipped) shall be captured throughout the study season.
  - No more than 250 juvenile sDPS green sturgeon shall be captured throughout the study season.
  - No more than 100 adult CCV steelhead shall be captured throughout the study season.
  - No more than 10 adult sDPS green sturgeon shall be captured throughout the study season.

- Each study season, no more than 2 percent cumulative mortality of fish captured in the traps will be allowed for each listed species, broken down by life stage. Life stages will either be the adult form or the juvenile form of the listed species. During each study season, a running cumulative sum of each listed species captured in fyke traps will be kept whether found alive, moribund, or dead. The number of total mortalities found either in the net during net recovery, seriously injured but alive in the traps, dying during resuscitation efforts, or dying while trying to release them back into the water (*i.e.*, never recover) will be kept. The total number of mortalities will be divided by the total number of each listed species observed in the traps and this value used to determine the cumulative mortality over the season, which shall not exceed 2 percent for the study season.

- A cap on lethal individual take limits per each life stage and by species will be applied for the study season. Lethal Individual take limits will be defined by the following parameters:
  - No more than 5 mortalities for juveniles of each listed species,
  - No more than 2 mortalities for adult Central Valley spring-run Chinook salmon or California Central Valley steelhead (unclipped),
  - No more than 1 mortality for adult sDPS of North American green sturgeon will be allowed each season.
  - For Chinook salmon, the “river model” for length-at-date run determinations will be used for immediate field identification of juveniles and assignment to the appropriate run (the “river model” is appropriate as fish have not started rearing in the Delta yet). An adult Chinook salmon will be any fish greater than 400 mm fork length.
  - For the sDPS of North American green sturgeon, an “adult” will be considered as a fish greater than 1,000 mm fork length.

2.8.2 Effect of the Take

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

2.8.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon resulting from implementation of the action.

1. **Reclamation shall remove the fyke traps from the water or cover with fish excluders when water temperatures reach or exceed 22.5°C. Fyke traps shall not be re-deployed until temperatures decrease below 22.5°C.**

2. Reclamation shall monitor the projected weather patterns and river conditions and real time fish monitoring data during the implementation of the DCC Fall-run Chinook Monitoring Project.

3. Reclamation shall keep logs of all water temperatures, dissolved oxygen concentration/ saturations, the number and species of fish captured, the number of mortalities, and number resuscitated, and make these logs available to NMFS upon request.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Bureau of Reclamation or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Bureau of 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) **Reclamation shall remove the fyke traps from the water when water temperatures reach or exceed 22.5°C. Fyke traps shall not be re-deployed until temperatures decrease below 22.5°C.**

    a) When nets are pulled to shore, all fish or other animals collected shall be released. All listed fish shall be checked for physiological condition and injuries. Uninjured and active fish shall be released immediately back into the water at the location of capture following measurement of fork length. Fish that are not active or are bleeding shall be resuscitated prior to release. Fish that must be resuscitated will be measured prior to their release, but these measurements shall occur after the fish has recovered so as not to delay getting the fish back into the water and adding additional stress during the measurement process.

    b) Data shall be collected each time the traps are checked, which shall include: numbers of fish captured by species, including number of listed species, body length (fork length), physical condition, number of mortalities (both immediate and fish dying during resuscitation), and assessment of run classification for Chinook salmon based on the length-at-date criteria, as well as the physical data (*e.g.*, water temperature, oxygen concentrations and saturation, soak times for nets). This information shall be emailed to NMFS staff on a daily basis when traps are deployed (email to: Kristin.McCleery@noaa.gov).

2) **Reclamation shall monitor the projected weather patterns and river conditions and real time fish monitoring data during the implementation of the DCC Fall-run Chinook Monitoring Project.**

   a) Reclamation shall monitor the river flow gages at Wilkins Slough and Balls Ferry on the Sacramento River, and stream flow gages on Deer and Mill creeks for flow increases. Reclamation shall also monitor the river guidance plots for the Sacramento River for flow increases. If flows are expected to increase more than 50 percent in a given 24-hour period or exceed 400 m^3 sec^{-1} (≈14,000 cfs) at Wilkins Slough, or 95 cfs at the Deer or Mill creek gages, then Reclamation shall contact NMFS to discuss ongoing operations and modifications to the monitoring project. These increases in flows typically signal the onset of juvenile winter-run or CV spring-run emigration, respectively, into the lower Sacramento River and the northern Delta.

      Guidance Plots:
      i) Sacramento River at RBDD:
      http://cdec.water.ca.gov/guidance_plots/RDB_gp.html;
      ii) Sacramento River at Fremont Weir:
      http://cdec.water.ca.gov/guidance_plots/FRE_gp.html)

      River Flows:
      i) Sacramento River at Bend Bridge:
      http://cdec.water.ca.gov/cdecstation/?sta=BND
      ii) Deer Creek near Vina:
      http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=DCV
      iii) Mill Creek near Los Molinos:
      http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=MLM
      iv) Sacramento River at Wilkins Slough:
      http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=WLK

   b) Reclamation shall also monitor the daily catches of the Knights Landing RSTs, the Sacramento trawls at Sherwood Harbor, and the northern Delta and lower Sacramento River region beach seines for catch of listed salmonids throughout the implementation of the DCC Fall-run Chinook salmon Monitoring Project. If these monitoring efforts catch listed fish, Reclamation shall contact NMFS to discuss ongoing operations and modifications to the monitoring project to protect listed fish coming into the action area.

3) **Reclamation shall keep logs of all water temperatures, dissolved oxygen concentration/ saturations, the number and species of fish captured, the number of mortalities, and number resuscitated, and make these logs available to NMFS upon request.**

a) Reclamation shall provide a weekly summary of the collected data to NMFS staff via email (Kristin.McCleery@noaa.gov) as well as a hard copy to the following address:

Assistant Regional Administrator
California Central Valley Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento, California 95814

b) Any Chinook salmon, steelhead or green sturgeon found dead or injured within 400 meters (0.25 mile) upstream or downstream of fishing gear deployment sites during the DCC fall-run Chinook salmon Monitoring Project shall be reported immediately to NMFS via fax or phone within 24 hours of discovery to:

Attention Assistant Regional Administrator,
NMFS California Central Valley Office
Fax at (916) 930-3623, or
Phone at: (916) 930-3600.

A follow-up written notification shall also be submitted to NMFS which includes the date, time, and location that the carcass or injured specimen was found, a color photograph, the cause of injury or death, if known, and the name and affiliation of the person who found the specimen. Written notification shall be submitted within 72 hours of discovery to:

Assistant Regional Administrator
California Central Valley Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento, California 95814

Any dead specimen(s) should be placed in a cooler with ice and held for pick up by NMFS personnel or an individual designated by NMFS to do so.

c) Reclamation shall make the log book available to any personnel from NMFS' Office of Law Enforcement upon request for review of compliance with the Incidental Take Statement and these terms and conditions.

d) Immediate notification of NMFS staff via email (Kristin.McCleery@noaa.gov) with follow-up fax or phone call to the numbers in 3(b) should any conditions of the ITS limits be exceeded.

e) At the end of each study season, Reclamation shall provide a report to NMFS containing a summary of:

i) all of the environmental conditions encountered during the gear deployment,
ii) the numbers of fish captured by species or run by gear type,
iii) the number of fish mortalities by species and run, particularly all listed fish species,
iv) the number of fish requiring resuscitation and their final disposition,
v) A record of all encounters or observations of marine mammals in the action area,
vi) The completed annual report is due within 2 months of study completion (February 1) and shall be sent to the address in 3(a) above.

2.9 Conservation Recommendations

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

1. The Bureau of Reclamation should conduct or fund studies to help quantify fish losses at water diversions, and prioritize fish screen projects for future funding.

2. The Bureau of Reclamation should conduct or fund studies to help determine movement and survival of listed fish through the Delta in response to water conveyance operations of the SWP and CVP. This can include support for ongoing studies such as acoustic tagging studies, predation studies, contaminant studies, or support for the infrastructure that supports these studies (boats, crews, acoustic receiver arrays, RSTs, *etc.*) conducted by other Federal, State, or educational institutions.

3. The Bureau of Reclamation should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects within the Delta region and further the implementation of the Central Valley Salmon Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and California Central Valley steelhead.

2.10 Reinitiation of Consultation

This concludes formal consultation for the DCC Fall-run Chinook salmon Monitoring Project.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

2.11 “Not Likely to Adversely Affect” Determinations

NMFS does not anticipate the proposed action will result in adverse effects to the designated critical habitats for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon.

Within the action area, the relevant PBFs of the designated critical habitat for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon are migratory corridors and rearing habitat. The project is unlikely to demonstrably affect these PBFs. It will have minimal transitory effects on the functioning of the critical habitat as a migratory corridor during the deployment of the receiver “A7” (Figure 20, Sacramento River downstream of the DCC junction). There will be temporary effects to this area of benthic substrate, but it will have negligible effects on the functioning of the designated critical habitat and will be transitory due to the temporary nature of the deployment of the acoustic equipment (2 months for the 2016 study season).

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

Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect Essential Fish Habitat (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. For the purposes of interpreting the definition of EFH, “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means habitat required to support a sustainable fishery and a healthy ecosystem; and, “spawning, breeding, feeding, or growth to maturity” covers all habitat types used by a species throughout its life cycle.

This analysis is based, in part, on the EFH assessment provided by Reclamation and descriptions of EFH for Pacific coast salmon as described in Amendment 18 to the Pacific Coast Salmon Plan (Pacific Fisheries Management Council [PFMC], 2014) contained in the fishery management plans (FMP) developed by the PFMC and approved by the Secretary of Commerce.

The proposed Project area is within the region identified as EFH for Pacific salmon in Amendment 18 of the Pacific Coast Salmon FMP. Reclamation is receiving this consultation under the MSA for potential impacts to the EFH of Pacific salmon as a result of implementing the DCC Fall-run Chinook salmon Monitoring Project near the town of Walnut Grove in USGS Hydrologic Unit Codes (HUCs) 18040012 (Upper Mokelumne), 1804003 (San Joaquin Delta) and 18020163 (Lower Sacramento).

The PFMC has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 18 to the Pacific Coast Salmon FMP (PFMC 2014). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the USGS HUCs described in Amendment 18.

3.1 Essential Fish Habitat Affected by the Project

The geographic extent of freshwater EFH is identified as all water bodies currently or historically occupied by Council-managed salmon as described in Amendment 18 of the Pacific Coast Salmon Plan. In the estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the Exclusive Economic Zone (EEZ) (200 nautical miles or 370.4 km) offshore of Washington, Oregon, and California north of Point Conception. The proposed Project occurs in the area identified as “freshwater EFH”; as it is above the tidal influence where the salinity is above 0.5 parts per thousand.

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) recommend that the FMPs include specific types or areas of habitat within EFH as “habitat areas of particular concern” (HAPC) based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. Based on these considerations, the Council designated five HAPCs: (1) complex channels and floodplain habitats; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine SAV. No HAPCs occur within the Action Area or will be affected by the Project.

3.2 Adverse Effects on Essential Fish Habitat

The proposed Project is considered a fishing activity that affects EFH. However, since the Project is a scientific endeavor, its intent is not to kill or harvest fish for commercial or recreational consumption, but to catch, tag, and release the fish to continue their spawning migration. There will be some incidental bycatch of non-target fish besides adult fall-run Chinook salmon and there is the possibility that some fish may be captured in the fyke traps used in the study. The following is a list of the expected impacts to EFH associated with fishing activities:

1. *Removal of salmon carcasses* – There is the possibility that a handful of adult salmon will die in the study from entrapment in the fyke traps and thus not be available to transport their marine derived nutrients and minerals to the spawning grounds. Adult salmon carcasses provide valuable marine derived nutrients and minerals to the spawning areas used by these fish. Upon their deaths after spawning, the nutrients contained in the bodies of the adult salmon become available to the riverine areas in which they die, nourishing a cascade of organisms in both the terrestrial and aquatic ecosystems (PFMC 2014). The impacts of the study are likely to be trivial and unmeasurable due to the small number of mortalities expected in the study.

2. *Vessel operations* – Operations of the vessels used to deploy and retrieve the equipment in the action area may cause sediment to be resuspended from the channel bottom and banks due to propeller wash, wakes, and anchoring. Resuspended sediment increases turbidity, may resuspend contaminants in the channel sediments, smother organisms and plants in the waterways, and reduce primary and secondary production by blocking sunlight needed for photosynthesis. In addition, vessels can be a source of chemical contaminants and sound pollution (PFMC 2014) that will adversely affect aquatic systems and organisms.

3. *Harvest of prey species* – There is the potential that the traps deployed during implementation of the Project will catch and kill aquatic organisms that serve as prey species for juvenile Chinook salmon. These species could include fish such as threadfin shad, juvenile American shad, small cyprinid fish, and smelts. Two inch mesh size is large enough that the traps deployed for the 2016 study season will not catch the invertebrate forage base primarily utilized by juvenile salmonids (amphipods, mysids, isopods, chironomids, *etc*.).

3.3 Essential Fish Habitat Conservation Recommendation

1. Reclamation will implement the terms and conditions described in the ITS. Fyke traps will be retrieved during periods of high water temperatures and process captured fish quickly to reduce mortality related to capture and release from the traps. The use of fyke traps instead of fyke nets and trammel nets (used in last year's study) reduces the chance of injury and eliminates any chance of entanglement, however, there is still potential for injury or mortality of entrapped fish, particularly if a large number of fish are present. Terms and Conditions 1 and 2 will address adverse effects related to removal of salmon carcasses from the watershed and reductions in the harvest of prey species (EFH adverse effect numbers 1 and 3).

2. Vessels will be maintained in good condition so that the engines are operating at optimal performance with no fluid leaks or discharges to the water. This will reduce or eliminate potential contaminants from entering the water due to their operations via exhausts or leaks. This addresses adverse effect number 2 above.

3. Vessels will operated in such a way as to reduce wakes and prop wash where sediments can be resuspended from the banks or from the channel bottoms. Vessels should not be operated so that large wakes are generated in confined areas of the channel or in shallow waters where the prop wash can interact with the channel bottom and resuspend sediment. This addresses adverse effect number 2 above.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, upon the freshwater EFH contained in the action area.

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. MARINE MAMMALS

Reclamation has determined that there is the potential for marine mammals to occur within the action area, but the Project, as described, is not likely to adversely affect either California sea lions (*Zalophus californianus*) or harbor seals (*Phoca vitulina richardii*). Project elements described in section 1.3.3.5 *Best Management Practices/ Conservation Measures* include fitting each fyke trap with a mammal excluder cross bar. NMFS also provided procedures in the terms and conditions of the biological opinion to reduce the potential for seal-net interactions (Term and Condition #4).

NMFS believes these study operating procedures will eliminate the potential for any adverse seal net interactions related to the carrying out of the DCC fall-run Chinook salmon monitoring Project. Therefore application for a Marine Mammal Protection Act Incidental Harassment Authorization or Letter of Authorization for the incidental take of a marine mammal during this

Project is not required. However, NMFS advises Reclamation that there is no authorization for the take or harassment of any marine mammals should that event occur, no matter how unlikely it is. Should the Project result in the incidental take of a marine mammal, Reclamation must suspend fishing operation associated with this study and contact NMFS for further instructions.

5. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

5.1 Utility

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

5.2 Integrity

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

5.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

6. REFERENCES

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

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7. APPENDICES

Tables:

Table 10: Summary table of monthly winter-run and spring-run Chinook salmon loss and Combined total salvage and loss of California Central Valley steelhead at the CVP and SWP fish collection facilities from water year 1999-2000 to water year 2008-2009. Data from Reclamation's Central Valley Operations web site: (http://www.usbr.gov/mp/cvo/)

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	1558	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	8	22	0	0	0	6553
%Wr/yr	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	4673	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	4646	5901	960	0	NA	NA	NA	11582
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	1358	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	28174	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	

Table 11: The proportion of juvenile Chinook salmon and steelhead production entering the Delta from the Sacramento River by month.

Month	Sacramento River Total[1,2]	Fall-Run[3]	Spring-Run[3]	Winter-run[3]	Sacramento Steelhead[4]
January	12	14	3	17	5
February	9	13	0	19	32
March	26	23	53	37	60
April	9	6	43	1	0
May	12	26	1	0	0
June	0	0	0	0	0
July	0	0	0	0	0
August	4	1	0	0	0
September	4	0	0	0	1
October	6	9	0	0	0
November	9	8	0	03	1
December	11	0	0	24	1
Total	100	100	100	100	100

Notes:

[1] Mid Water trawl data

[2] All runs combined

[3] Runs from Sacramento River basin only

[4] Rotary screw trap data from Knights Landing

Source: SDIP Draft EIR/EIS 2005 Tables J-23 and J-24, Appendix J.

Table 12: Percentage of adult Chinook salmon passing above Red Bluff Diversion Dam by month.

Month	Fall-run	Late-fall-run	Spring-run	Winter-run
January	0	17.5	0	3.75
February	0	17.5	0	13.75
March	0	6.25	1.25	37.5
April	0	1.25	1.25	25
May	0	0	4.5	10
June	0	0	10.5	7
July	2.5	0	15	1.5
August	10	0	25	1.5
September	32.5	0	27.5	0
October	40	20	15	0
November	12.5	17.5	0	0
December	2.5	20	0	0
Source: Adapted from Vogel and Marine (1991), averaging wet and dry years and assuming midpoints for values denoted as 'greater than' or 'less than' by Vogel and Marine (1991).				

Source: DWR 2010. Biological Assessment for the 2011 Georgiana Slough non-physical barrier study for NMFS managed species. ICF International. November 2010.

Table 13: Recovery of winter-run (WR) sized juvenile Chinook salmon in the Knights Landing Rotary screw traps (water years 2001 to 2012). Data is from CDFW.

Water years = WY

Water year Types: Critical (C), Dry (D), Below Normal (BN), Above Normal (AN), Wet (W). Water year type is based on the 60-20-20 index for the Sacramento River basin.

WR designation is based on size at date criteria.

Table 14: Recovery of winter-run (WR) sized juvenile Chinook salmon in the Sacramento River Trawls near Sherwood Harbor (water years 2008 to 2014). Data is from USFWS Delta Juvenile Fish Monitoring Program.

	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	-2011 to	2011-2012
WY Type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN
First WR at KL	11/6/2000	11/16/2001	10/11/2002	10/6/2003	10/29/2004	10/11/2005	10/6/2006	12/12/2007	12/29/2008	10/15/2009	10/11/2010	10/10/2011
25% @ KL	1/19/2001	11/27/2001	12/17/2002	12/9/2003	12/11/2004	12/3/2005	12/15/2006	12/31/2007	1/26/2009	10/28/2009	12/8/2010	1/23/2012
50% @ KL	1/29/2001	12/11/2001	12/22/2002	12/11/2003	12/13/2004	12/6/2005	12/17/2006	1/12/2008	2/24/2009	1/20/2010	12/17/2010	1/25/2012
75% @ KL	2/23/2001	1/4/2002	1/4/2003	12/20/2003	1/5/2005	12/24/2005	12/30/2006	1/28/2008	2/27/2009	1/26/2010	12/23/2010	1/27/2012
100% @ KL	4/25/2001	4/24/2002	4/21/2003	4/5/2004	4/22/2005	4/18/2006	3/13/2007	3/3/2008	4/6/2009	4/16/2010	4/9/2011	4/11/2012

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
WY Type	C	D	BN	W	BN	D	C
First WR at Sac	1/7/2008	12/22/2008	10/23/2009	10/29/2010	1/25/2012	11/23/2012	2/9/2014
25% @ Sac	1/7/2008	2/17/2009	11/4/2009	12/12/2010	3/15/2012	11/25/2012	2/13/2014
50% @ Sac	1/16/2008	2/17/2009	2/5/2010	2/19/2011	3/17/2012	11/26/2012	2/15/2014
75% @ Sac	2/5/2008	2/18/2009	2/17/2010	3/18/2011	3/29/2012	11/29/2012	3/4/2014
100% @ Sac	3/3/2008	2/27/2009	2/26/2010	4/15/2011	4/13/2012	12/7/2012	4/4/2014

Table 15: Recovery of spring-run (SR) sized juvenile Chinook salmon in the Knights Landing Rotary screw traps (water years 2001 to 2012). Data is from CDFW. Abbreviations are the same as in Table 13. Release of CNFH fall-run production fish overlap with wild spring-run Chinook salmon size.

	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011 to	2011-2012
WY Type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN
First SR at KL	12/20/2000	11/27/2001	12/16/2002	12/10/2003	12/11/2004	11/14/2005	12/13/2006	10/19/2007	10/27/2008	10/26/2009	12/9/2010	10/24/2011
25% @ KL	2/26/2001	2/22/2002	12/19/2002	12/12/2003	1/4/2005	12/21/2005	12/12/2006	1/9/2008	3/19/2009	4/14/2010	1/4/2011	3/30/2012
50% @ KL	3/28/2001	4/23/2002[a]	1/4/2003	12/24/2003	3/31/2005	2/7/2006	3/18/2007	1/13/2008	3/25/2009	4/15/2010	2/27/2011	4/2/2012
75% @ KL	4/18/2001[a]	4/25/2002[a]	4/9/2003	3/22/2004	4/20/2005[a]	4/19/2006[a]	4/19/2007[a]	2/7/2008	4/14/2009	4/16/2010	4/7/2011	4/13/2012
100% @ KL	5/14/2001	5/14/2002	5/9/2003	5/12/2004	5/12/2005	5/6/2006	5/14/2007	5/15/2008	5/12/2009	5/17/2010	5/2/2011	5/10/2012
(a) CNFH FR Release	4/13/2001	4/4/2002	4/18/2003	4/16/2004	4/15/2005	4/14/2006	4/12/2007	4/23/2008	4/9/2009	4/8/2010	4/14/2011	4/19/2012

Table 16: Recovery of spring-run (SR) sized juvenile Chinook salmon in the Sacramento River Trawls near Sherwood Harbor (water years 2008 to 2014). Data is from USFWS Delta Juvenile Fish Monitoring Program.

	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
WY Type	C	D	BN	W	BN	D	C
First SR at Sac	1/7/2008	2/23/2009	2/3/2010	12/8/2010	1/25/2012	12/3/2012	2/11/2014
25% @ Sac	2/24/2008	4/14/2009	4/13/2010	4/15/2011	3/26/2012	4/9/2013	3/7/2014
50% @ Sac	4/12/2008	4/17/2009	4/15/2010	4/19/2011	3/30/2012	4/16/2013	4/7/2014
75% @ Sac	4/21/2008	4/23/2009	4/22/2010	4/20/2011	4/16/2012	4/17/2013	4/11/2014
100% @ Sac	5/2/2008	5/7/2009	5/11/2010	5/10/2011	5/3/2012	5/7/2013	5/13/2014

Table 17: End of month cumulative percentiles of the annual catch of winter-run Chinook salmon at the Knights Landing RSTs for water years 2001 through 2012. Data is from CDFW. Abbreviations are the same as in Table 13.

	Water Year													
	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Mean	Stdev
WY Type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN		
End of October	0	0	0.4	0.3	0.1	1.6	2.1	0	0	26.5	15	4.8	4.23	8.22
End of November	0.6	43	1.2	0.5	4.9	20.2	3.8	0	0	29.4	19.1	5.7	10.70	14.09
End of December	6.7	71.9	65.9	85.2	64.2	91.8	80.9	2.5	22.3	32.9	82.3	6.7	51.11	34.34
End of January	60	93	94.7	92.9	92	95.4	90.8	78.8	36.9	90	94.4	86.7	83.80	17.81
End of February	81.6	97	97.7	97.2	97.5	98.5	99.5	99.1	82.3	94.7	96.1	91.4	94.38	6.20
End of March	99	98.8	99.3	99.9	99.9	99.6	100	100	99.2	98.8	99.2	95.2	99.08	1.30
End of April	100	100	100	100	100	100	100	100	100	100	100	100	100.00	0.00
End of May	100	100	100	100	100	100	100	100	100	100	100	100	100.00	0.00

Table 18: End of month cumulative percentiles of the annual catch of spring-run Chinook salmon at the Knights Landing RSTs for water years 2001 through 2012. Data is from CDFW. Abbreviations are the same as in Table 13.

	Water Year													
	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Mean	Stdev
WY Type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN		
End of October	0	0	0	0	0	0	0	0.3	0.2	0.2	0	0.1	0.07	0.11
End of November	0	5.5	0	0	0	0.2	0	0.3	0.2	0.2	0	0.1	0.54	1.57
End of December	1	17.6	47.7	56	21.4	42.5	17.5	0.9	0.8	0.2	18.7	0.1	18.70	20.11
End of January	10.2	21.8	58.2	66	32.7	47.1	20.2	64.7	1.8	8.5	33.3	1.2	30.48	23.83
End of February	26	27.3	61	69.6	37	58.9	45.4	80.7	19.8	10.2	50.6	1.7	40.68	24.49
End of March	58.7	33.1	68.8	79.4	51.1	65.8	52.2	82.8	52.4	14.3	67.2	36.1	55.16	19.91
End of April	93.4a	92.2	99.8	98.7	99.1	98.9	96.4	97.8	99.4	99.5	99.6	99.2	98.24	2.23
End of May	100a	100	100	100	100	100	100	100	100	100	100	100	100.00	0.00

7. Appendices

Figures:

Figure 19: Delta Cross Channel study site, depicting Snodgrass Slough (yellow), Dead Horse Island Cut (orange), the Sacramento River (light blue), the DCC (dark blue), the north (red), south (green), and the mainsteam (white) Mokelumne River.

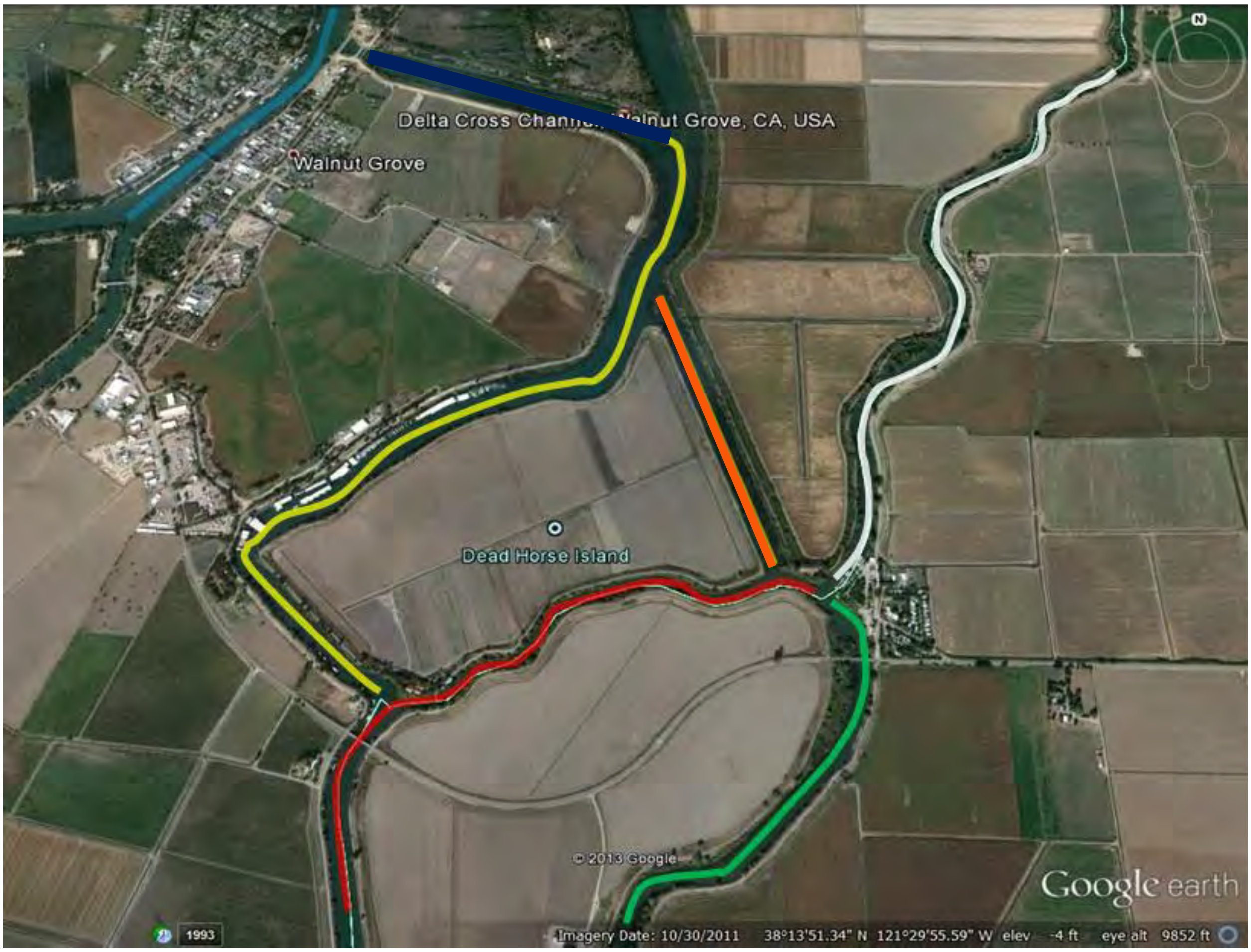


Figure 20: Location of Project study components. Proposed locations for installation of acoustic receivers (yellow "A") and Didson units (green “D”) to monitor movement patterns of individual adult fall-run Chinook salmon straying from the Mokelumne River, through the Delta Cross Channel, into the Sacramento River. Fyke trap locations in the north and south forks of the Mokelumne River (orange “NF” for North Fork and “SF” for South Fork). A third fyke trap will be installed in Dead Horse Cut.

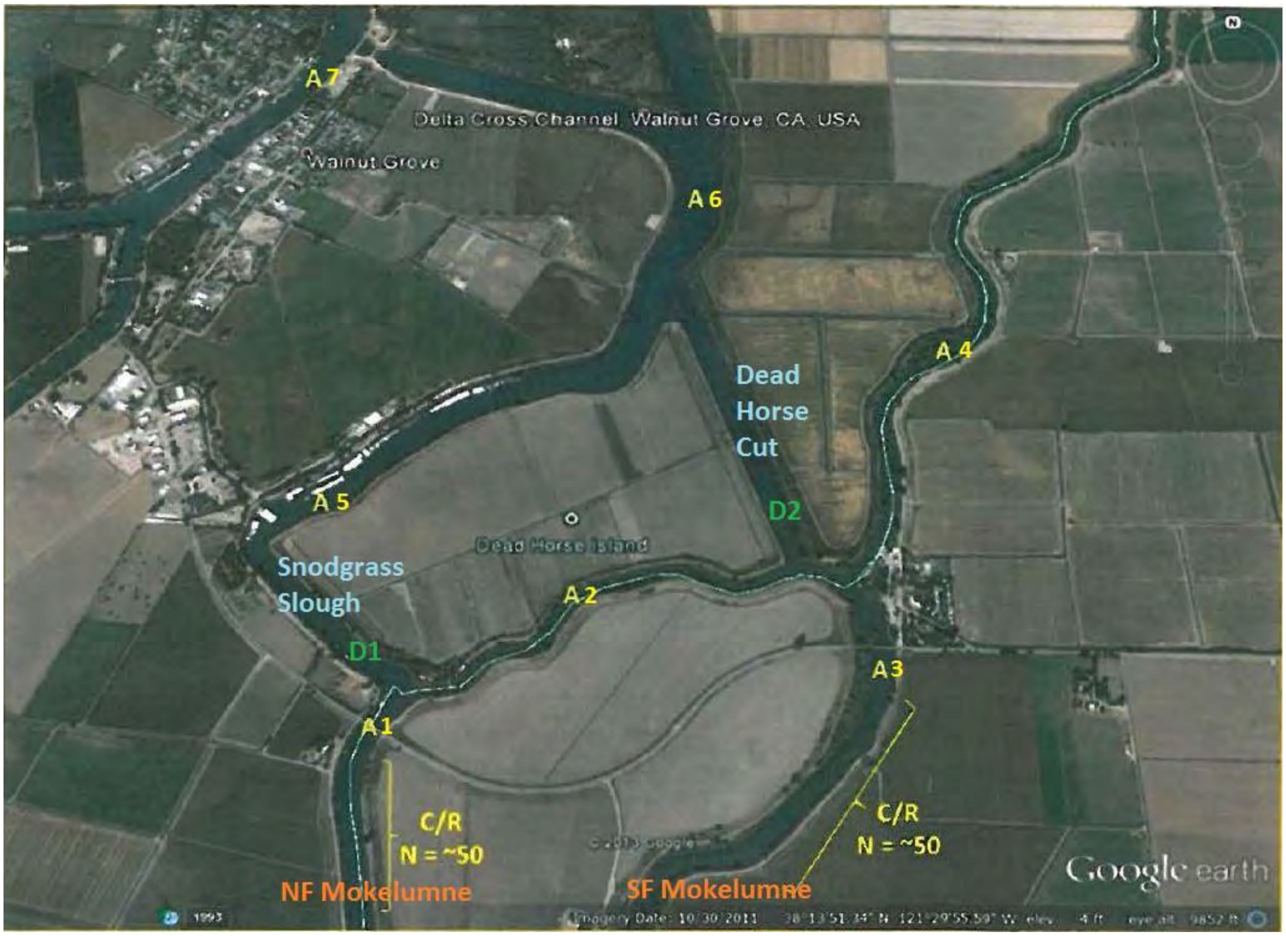


Figure 21: Example of typical job box. Equipment locked safely inside. Solar panel used to charge deep cycle batteries. Depending on job box location, the orientation and location of the solar panels will vary to provide the most sun coverage.

Figure 22: Tripod ("A") used for transducer deployment. A transducer ("B") will sit on small post near open end of tripod, and can be rotated using a custom made bracket ("C").

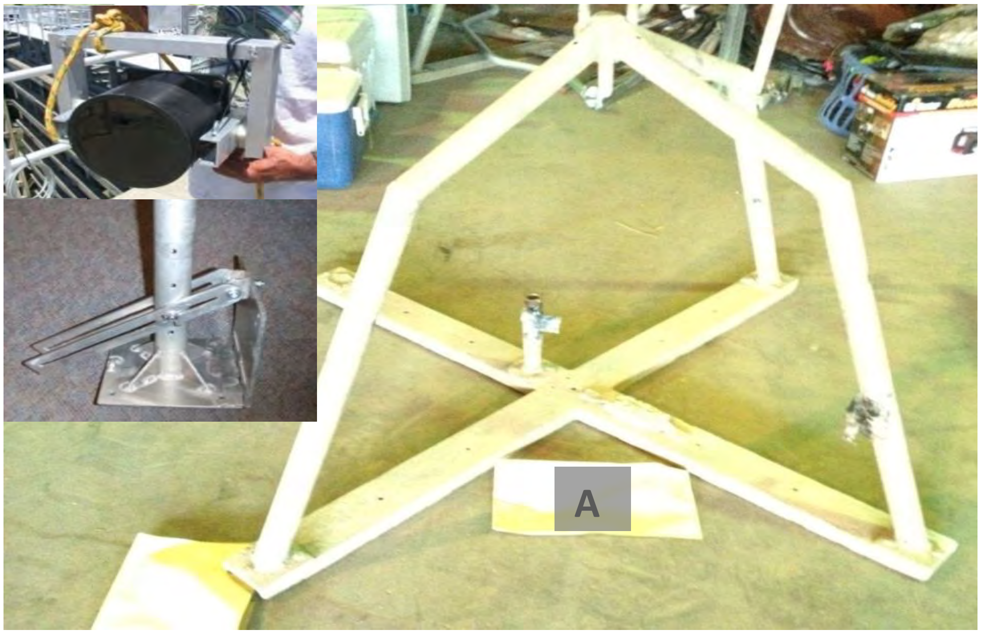


Figure 23: Small receivers (insert) attached vertically to a rope. The rope is attached to a buoyant device and anchored in position to restrict movement and allow the receiver to remain in a vertical position.

Figure 24: Action area of the DCC Fish Monitoring Project.
Red highlighted channels are the extent of the project's action area.

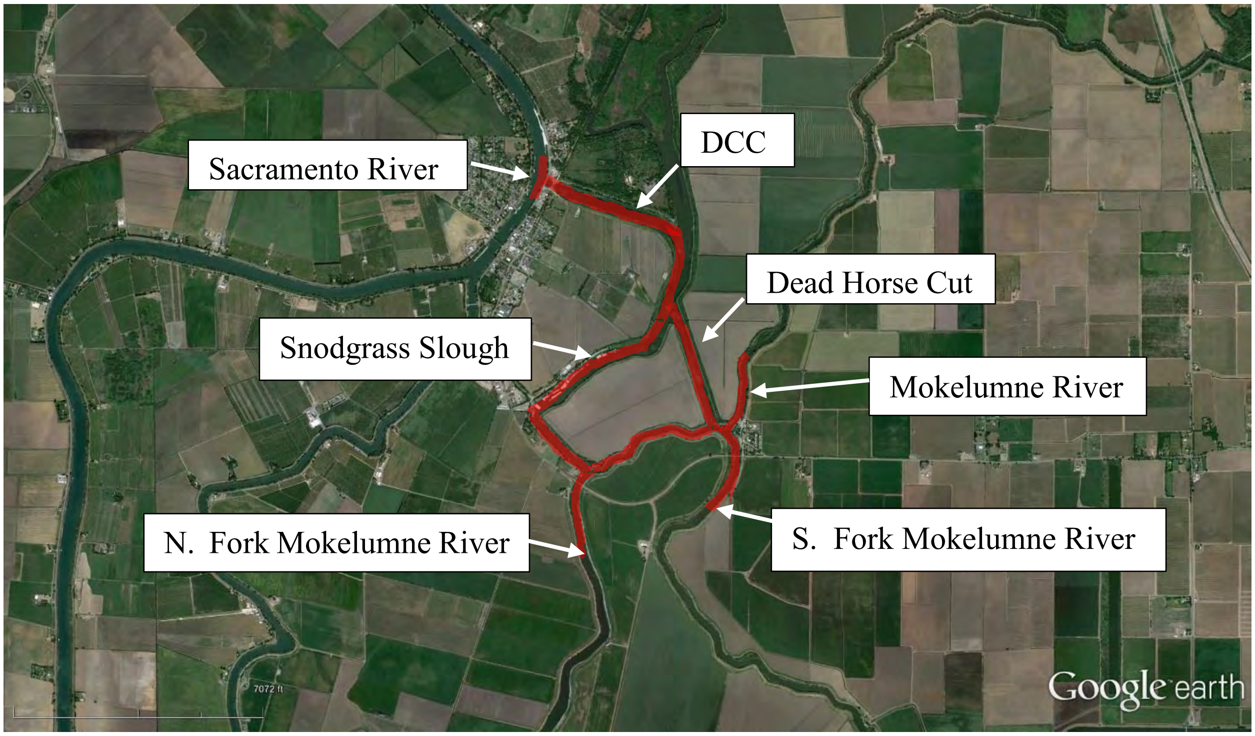


Figure 25: Conceptual model for exposure of juvenile fish from the Sacramento River to the fishing gears in the DCC Fall-run Chinook salmon Project. WRCS = Winter-run Chinook salmon, SRCS = Spring-run Chinook salmon, SH = steelhead, GS = sDPS green sturgeon.

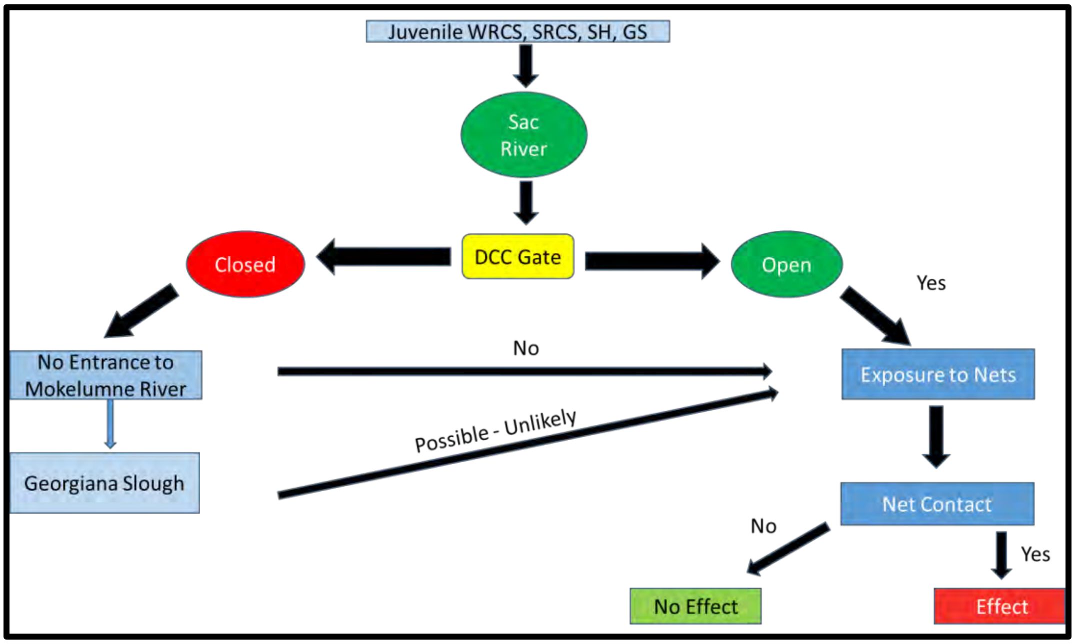
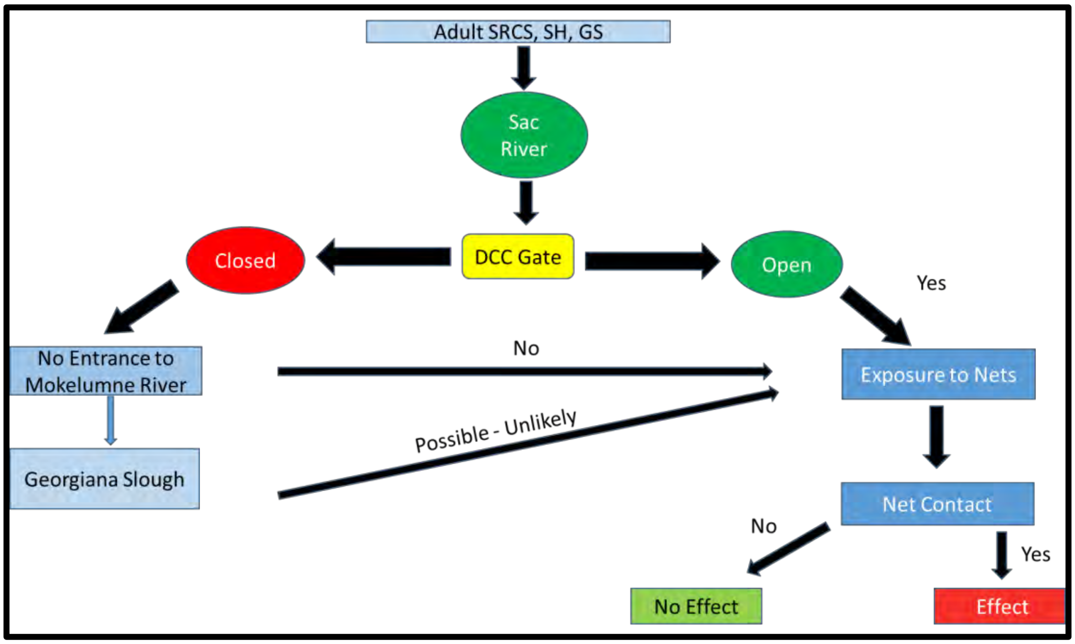


Figure 26: Conceptual model for exposure of adult fish from the Sacramento River to the fishing gears in the DCC Fall-run Chinook salmon Project.



pFigure 27: Conceptual model for exposure of adult fish from the Mokelumne River to the fishing gears in the DCC Fall-run Chinook salmon Project.

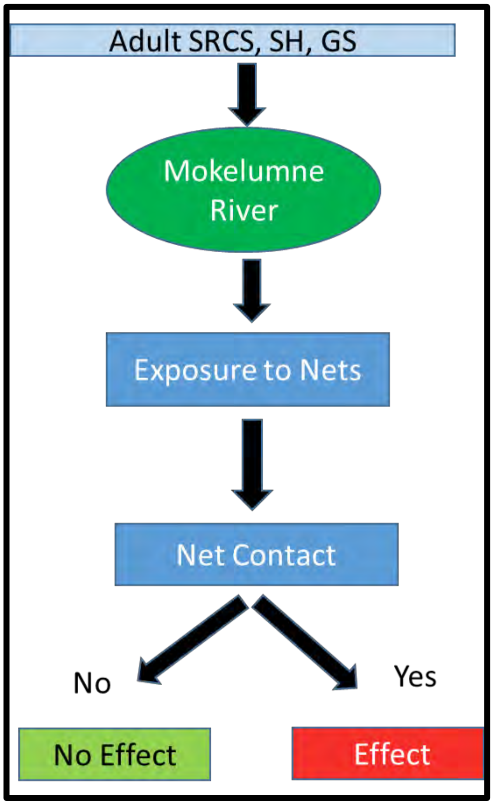


Figure 28: Conceptual model for exposure to nets with associated outcomes.

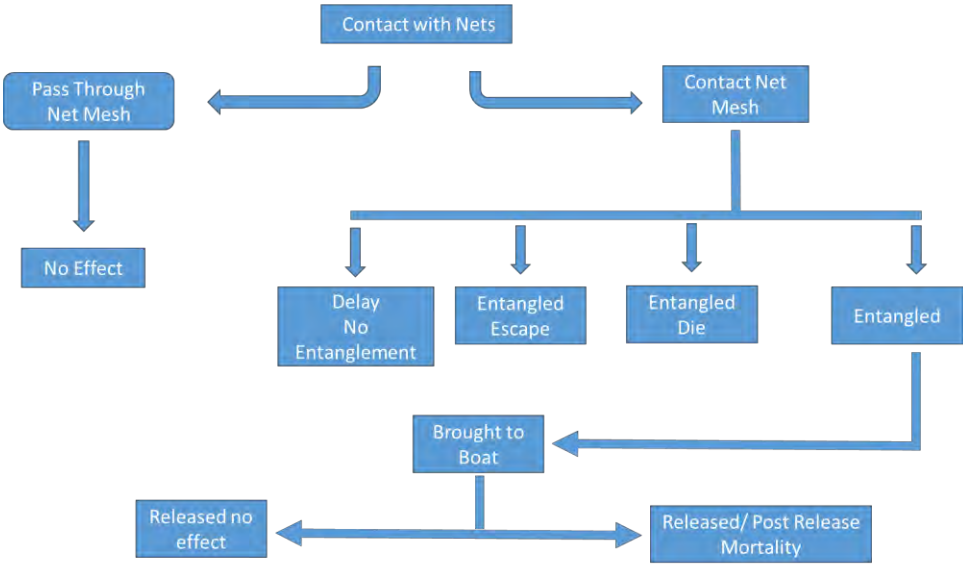


Figure 29: Water Temperatures in the **North Fork of the Mokelumne River** from August 1 through Novemebr 30 for 2011, 2012, 2013, 2014. Blue boxes indicate when the Delta Cross Channel (DCC) gates were closed. Water temperature data from CDEC (http://cdec.water.ca.gov/cgi-progs/queryF?NMR). DCC gate data from: (http://www.usbr.gov/mp/cvo/vungvari/Ccgates.pdf)

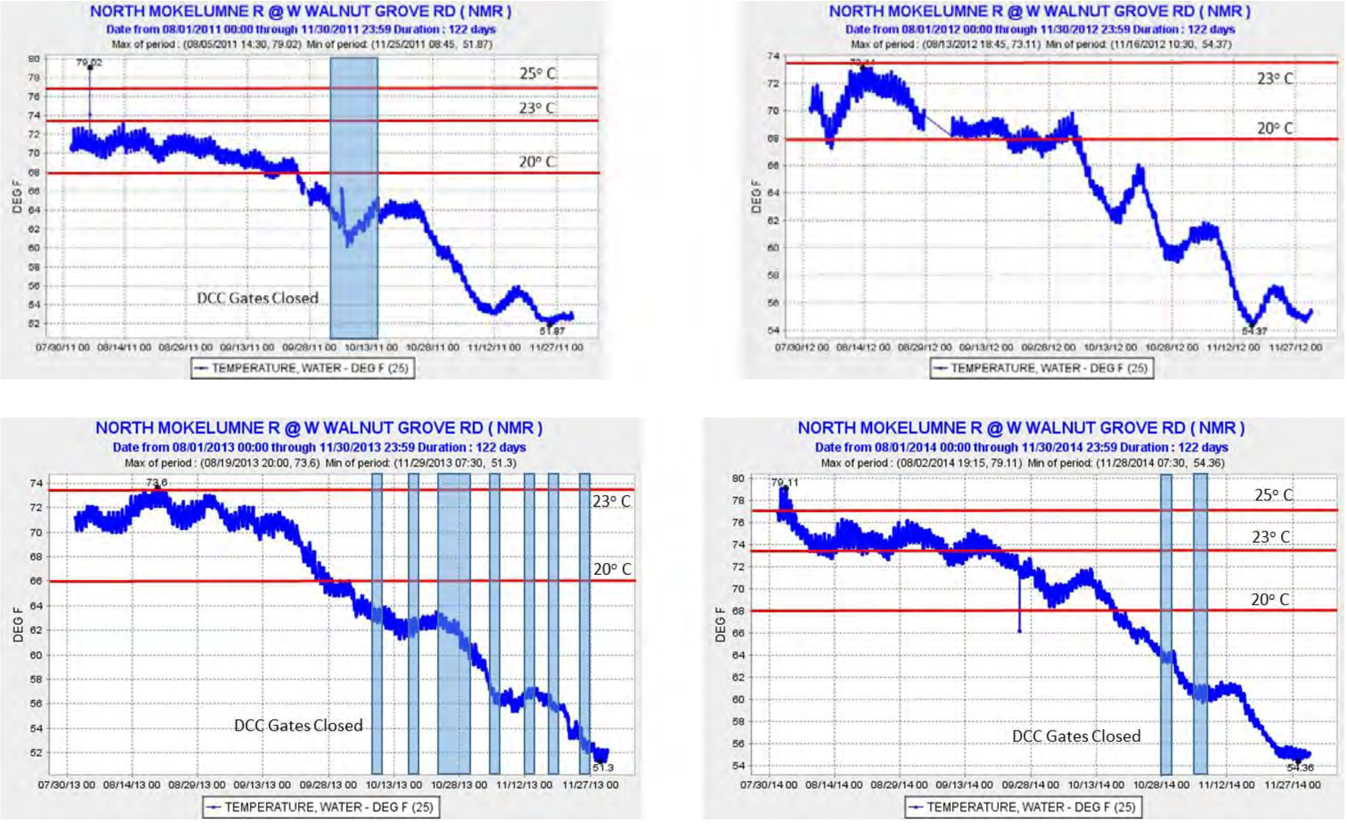


Figure 30: Water Temperatures in the **South Fork of the Mokelumne River** from August 1 through Novemebr 30 for 2011, 2012, 2013, 2014. Blue boxes indicate when the Delta Cross Channel (DCC) gates were closed. Water temperature data from CDEC: (http://cdec.water.ca.gov/cgi-progs/queryF?SMR). DCC gate data from: (http://www.usbr.gov/mp/cvo/vungvari/Ccgates.pdf)