UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

Refer to NMFS No: WCR-2018-9176

March 28, 2018

Michael J. Horn, Ph.D.
Manager
Fisheries and Wildlife Resources Group
U.S. Bureau of Reclamation
Technical Service Center
P.O. Box 25007
Denver, Colorado 80225-0007

Re: Endangered Species Act Section 7(a)(2) Biological Opinion for the 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Project (Reinitiation 2018)

Dear Dr. Horn:

Thank you for your letter of October 19, 2017, requesting reinitiation 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 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Project (Reinitiation 2018) (Project) with modifications to sampling methods and sampling periods for the 2018 and 2019 seasons of the Project. We also received your letter of February 5, 2018, responding to our request for additional information.

The enclosed biological opinion is based on information provided in the October 2016 biological assessment, supplemental information provided through mail, and email correspondence between NMFS and the U.S. Bureau of Reclamation. Based on new sampling methods that will be used in the 2018 and 2019 field seasons, reinitiation of ESA section 7 consultation was warranted and a new biological opinion was developed. The enclosed new biological opinion supersedes the original biological opinion, which was issued on April 5, 2017. A complete administrative record for this consultation is on file at the NMFS California Central Valley Office located in Sacramento, California.

NMFS analyzed the potential effects of the Project on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened Southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*), and their designated critical habitats in accordance with section 7 of the ESA.

In the enclosed biological opinion, NMFS concludes that the Project is not likely to 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 also determined that the Project is not likely to adversely affect the designated critical habitats for:

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

NMFS anticipates that some incidental take may occur in the form of death, injury, or harm to the species listed above during deployment of fishing equipment. Therefore, an incidental take statement with non-discretionary terms and conditions is included.

Please contact Kristin McCleery at the California Central Valley Office via e-mail at kristin.mccleery@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Barry A. Thom
Regional Administrator

Enclosure

cc: Copy to file: 151422-WCR2018-SA00422

Mr. Clarence Fullard (cfullard@usbr.gov), Fisheries and Wildlife Resources Group, U.S. Bureau of Reclamation, P.O. Box 25007, Denver, Colorado 80225-0007

Mr. Craig Weightman (craig.weightman@wildlife.ca.gov), Acting Regional Manager, California Department of Fish and Wildlife, Bay Delta Region, 7329 Silverado Trail, Napa, California 94558

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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Modification to the 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Project (Reinitiation 2018)

National Marine Fisheries Service (NMFS) Consultation Number: WCR-2018-9176

Action Agency: U.S. Bureau of Reclamation

Affected Species and NMFS' Determinations:

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

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

Issued By: ______________________________
Barry A. Thom
Regional Administrator

Date:

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LIST OF ACRONYMS

BA	Biological Assessment
CDFG	California Department of Fish and Game (through 2012)
CDFW	California Department of Fish and Wildlife (beginning in 2013)
C	Centigrade
cfs	Cubic Feet per Second
cm	Centimeters
CWT	Coded Wire Tag
CVP	Central Valley Project
DO	Dissolved Oxygen
DQA	Data Quality Act
DIDSON	Dual Frequency Identification Sonar Camera
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FL	Fork Length
Hz	Hertz
KHz	KiloHertz
ITS	Incidental Take Statement
m	Meter
mm	Millimeter
mg/l	Milligrams/Liter
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
NMFS	National Marine Fisheries Service
NTUs	Nephelometric Turbidity Units
PBF	Physical or Biological Feature
ppt	Parts per Thousand
Reclamation	U.S. Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
sDPS	Southern Distinct Population Segment
SWP	State Water Project
TFCF	Tracy Fish Collection Facility
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USFWS	United States Fish and Wildlife Service
VSP	Viable Salmonid Population

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We 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 (DQA) (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 NMFS' California Central Valley Office.

1.2 Consultation History

The release sites are part of the fish salvage facilities that were previously consulted on for the long-term operation of the Central Valley Project (CVP) and State Water Project (SWP). The NMFS biological opinion for the long-term operation of the CVP/SWP (NMFS 2009 Opinion) required predation studies to be conducted at the release sites. This Project was proposed to meet one or more of the required Reasonable and Prudent Alternative (RPA) actions in the NMFS 2009 Opinion.

A louver-bypass system for the Jones Pumping Plant intercepts fish that are entrained at the Tracy Fish Collection Facility (TFCF) in the south Delta. All fishes captured at the TFCF are transported by tanker trucks downstream to the release sites at the confluence of the Sacramento and San Joaquin rivers. The TFCF salvages and releases approximately 7,000,000 fish per year, including an average of 31,900 Federally protected Chinook salmon (Reclamation 2016).

Pursuant to RPA actions required in the NMFS 2009 Opinion, the U.S. Bureau of Reclamation (Reclamation) requested ESA section 7 formal consultation for the 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Project. The proposed Project was a necessary first step in meeting the requirements in Action IV.4.3(3), which states:

> "3) Release Site Studies shall be conducted to develop methods to reduce predation at the 'end of the pipe' following release of salvaged fish."

A second objective of the proposed Project is to meet RPA Action IV.4.3(4), which states:

> "4) By June 15, 2011, predation reduction methods shall be implemented according to

analysis in 3. By June 15, 2014, achieve a predation rate that has been reduced 50 percent from current rate."

Since a predation rate at the release sites has never been quantified, Reclamation's proposed Project attempts to quantify the current rate from which management actions can then be implemented and a reduction measured.

In July, 2016, Reclamation formed an interagency working group for the Project comprised of representatives from California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), California Department of Water Resources (DWR), and later on, NMFS. This team formulated the Project goals, specific details of the Project, and advised on permitting requirements.

The goal of the Project is to determine the predation rate in order to develop methods to reduce mortality at the release sites. This not only meets RPA Action IV.4.3(4) in the NMFS 2009 Opinion, but is a step towards meeting a recovery action identified in the Central Valley Chinook Salmon and Steelhead Recovery Plan (NMFS 2014). A priority one action (Del-1.23) in the recovery plan is to improve fish screening and salvage operations to reduce mortality from entrainment and salvage at the CVP and SWP export facilities. The Central Valley Recovery Plan calls for adaptively managing actions in the Delta that meet at a minimum, through-Delta juvenile survival rates of 57 percent for Sacramento River winter-run Chinook salmon (winter-run), 54 percent for Central Valley (CV) spring-run Chinook salmon (CV spring-run), and 59 percent for California Central Valley (CCV) steelhead originating from the Sacramento River; and in the San Joaquin River 38 percent for CV spring-run, and 51 percent for CCV steelhead (NMFS 2014). The Project is a first step in reducing predation at the CVP and SWP export facilities, which should (at least for salvaged fish) improve survival through the Delta.

- On October 21, 2016, NMFS received a request from Reclamation, with an enclosed BA, to initiate formal ESA section 7 consultation on the 2017 Sacramento-San Joaquin River Delta Release Site Predation Project. Reclamation determined that the proposed action was likely to result in incidental take or adverse effects to one or more individuals under NMFS jurisdiction.

- Subsequently, Reclamation clarified the request on November 16, 2016, and determined that the proposed 2017 Sacramento-San Joaquin River Delta Release Site Predation Project is "unlikely to adversely affect" Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSA).

- On November 18, 2016, NMFS responded to Reclamation that it had enough information to initiate formal consultation.

- On February 13, 2017, Reclamation modified its proposed action to extend the Project through year 2019 and added additional research equipment.

- On March 14, 2017, NMFS sent an email to Reclamation advising them of effect determinations, both clarifying those from Reclamation's cover letter and BA, and based

on NMFS's analyses. Specifically:
  - No determination necessary for Central Valley fall-run and late fall-run Chinook salmon (not ESA listed);
  - Likely to adversely affect for winter-run;
  - Consultation not warranted for California Central Coast steelhead (not present and no designated critical habitat in the action area);
  - Not likely to adversely affect critical habitats of winter-run, CV spring-run, CCV steelhead, and the Southern distinct population segment of North American green sturgeon (sDPS green sturgeon); and
  - The Project would not adversely affect Essential Fish Habitat, therefore, EFH consultation is not warranted.

- On March 16, 2017, Reclamation replied that they agreed with NMFS' determinations.

- On April 5, 2017, NMFS issued a biological opinion to Reclamation on the Project.

- On October 19, 2017, NMFS received a request from Reclamation for reinitiation of formal consultation for a change in methods for the remainder of the Project (2018 and 2019 seasons). Reclamation provided information on the new methods, and a "Justification" document. Reclamation determined that the proposed action was likely to result in incidental take or adverse effects to one or more individuals under NMFS jurisdiction.

- On December 7, 2017, NMFS issued Reclamation an insufficiency letter.

- On February 10, 2018, NMFS received Reclamation's response to NMFS' insufficiency letter.

- From February 22, 2018 to March 13, 2018, NMFS corresponded with Reclamation via email to acquire additional information regarding the new sampling methods and potential impacts to ESA listed species. On March 13, 2018, NMFS determined it had sufficient information to reinitiate formal consultation.

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02).

Reclamation proposes to add new sampling methods and remove trammel netting and photonic marking used in the 2017 Project. Original trammel netting methods were insufficient to measure predator abundance and composition at CVP/SWP fish release sites in the Delta. New methods to be used in 2018 and 2019 include tethering, hook and line surveys, and electrofishing surveys.

Dual Frequency Identification Sonar (DIDSON) camera technology may continue to be used in 2018 and 2019. Use of the DIDSON data will assist with estimating species-specific abundance of large predators (i.e., larger than 2.5 inches body depth) in close proximity to the release sites.

Acoustic arrays (receivers/hydrophones) will not be used in 2018, however, acoustic arrays may be used to detect acoustic-tagged fish during the 2019 season if funds are available. A list of methods for each year is provided in **Table 1** below.

Table 1. Sampling methods during each year:

2017	2018	2019
Trammel Nets	Tethering	Tethering
Photonic Marking	Hook and Line	Hook and Line
Gastric Lavage	Electrofishing	Electrofishing
DIDSON Cameras	DIDSON Camera	DIDSON Camera
Acoustic Arrays		Acoustic Arrays

Reclamation also proposes to extend the 2017 March through May sampling period to a March through June sampling period for the 2018 and 2019 seasons.

The goals of the Project are to:

1. Estimate total abundance of large fish, assumed to be predators, and species-specific abundance of predators, at the fish release sites during the juvenile Chinook salmon migration season (March through June in 2018 and 2019) at the SWP Curtis Landing and SWP Horseshoe Bend fish release sites and at two nearby control sites.

2. Estimate total and species-specific predation loss of released fish at multiple release sites during the juvenile Chinook salmon migration season (March through June in 2018 and 2019).

1.3.1 DIDSON Camera

DIDSON camera monitoring may be used again in 2018 or 2019 to estimate species-specific abundance of large predators (*i.e.,* larger than 2.5 inches body depth). Mobile DIDSON camera surveys would be employed to examine predators inhabiting the waters near release pipe outlets. 2018 and 2019 monitoring would be conducted around the two SWP release sites (Curtis Landing and Horseshoe Bend) and the two nearby control sites for approximately 0.5 hours per day, 3 days a week for 4 months (total of 6 hours each year). Last year's (2017) monitoring included other monitoring locations such as Emmaton and Antioch CVP release sites (**Figure 1**). DIDSON data collected by DWR at their release sites may be used by Reclamation instead of deploying their own gear during 2018 and 2019.

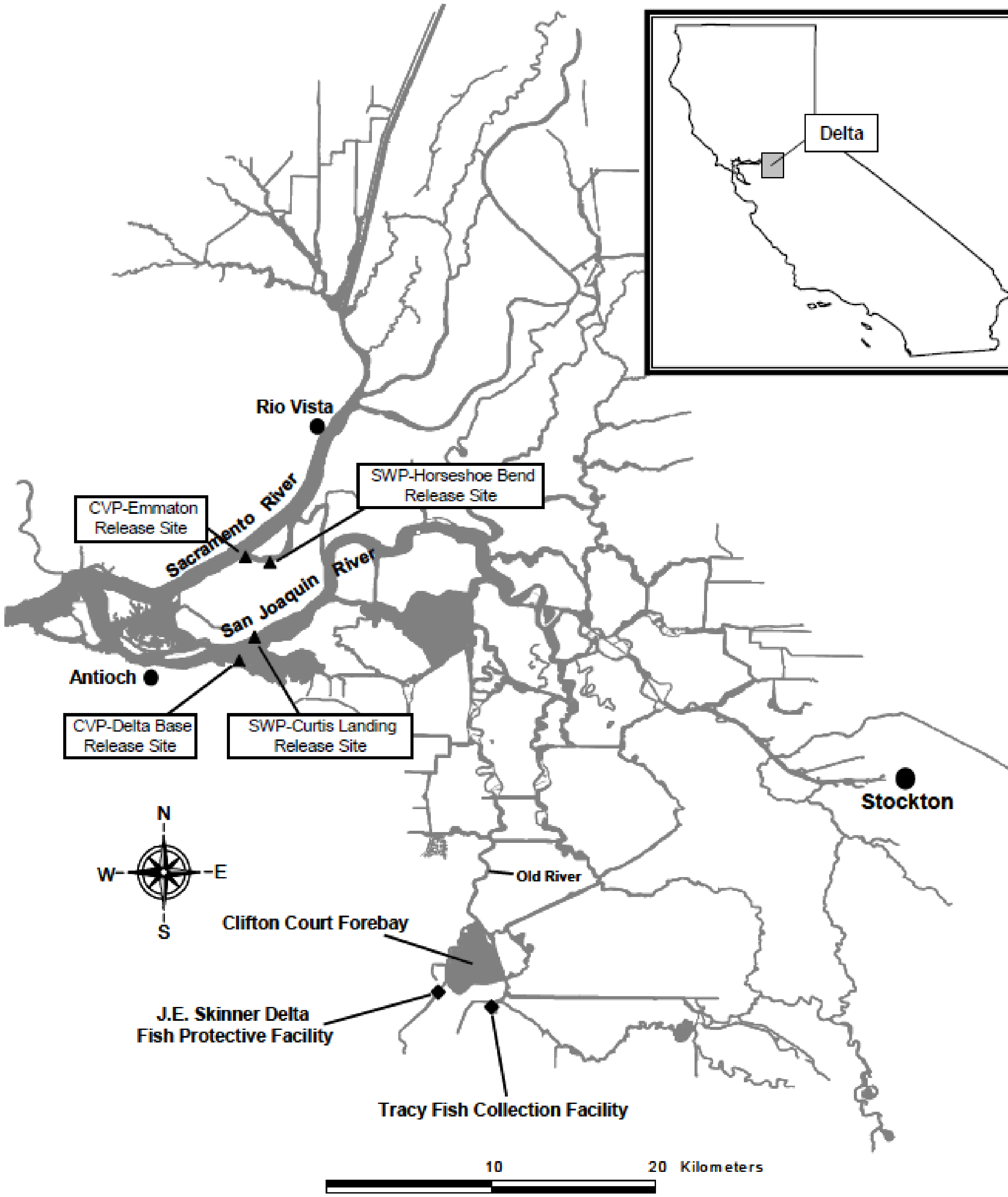

Figure 1. Locations of the Fish Salvage Facilities and release sites, in the Sacramento-San Joaquin Delta, California. Areas surrounding the SWP Curtis Landing and SWP Horseshoe Bend release sites will be sampled during the 2018 and 2019 seasons.

1.3.2 Acoustic Arrays (Receivers/Hydrophones)

On February 13, 2017, Reclamation sent a supplement to the BA, which added monitoring equipment and extended the Project to 2019. The additional equipment consists of newly developed predator-detection acoustic tags (PDAT) that detect when a fish is preyed upon. They expanded the Project to include the two release sites at the SWP and the installation of acoustic arrays (receivers/hydrophones) across the Sacramento River at Rio Vista and Sherman Island (**Figure 2**) in 2017. If funding allows, acoustic arrays will again be used in 2019 around Sherman Island, but will not be used at Rio Vista.

Figure 2. Locations of hydrophones (acoustic receiver arrays) at the Emmaton release site in 2017. 2019 placement of hydrophones will not include Rio Vista location (top right on map).

Reclamation proposes to continue to use VEMCO (https://vemco.com) acoustic transmitters (version V5 and V5-predation detection tags) in order to track hatchery Chinook salmon released from the release pipes. Acoustic tags are surgically inserted into juvenile hatchery salmon at the TFCF 2 weeks prior to release following standard tagging procedures. Tagged salmon will be added into the release truck with the rest of the salvaged fish prior to transport to the release site. Tagged fish will be tracked after release using stationary hydrophones (VEMCO HR2s), hydrophone arrays (VEMCO VR2Ws), and mobile boat-based acoustic tracking (VEMCO VR100) with a 180 kilohertz (KHz) hydrophone.

VEMCO hydrophones are small, lightweight listening devices. They will be tied to a rope that is both anchored to the bottom (using either a cinder block-style anchor, or a custom built steel tripod) and tied to a buoy, which will stay underwater and out of public sight, and deep enough to avoid conflicts with boat traffic. The entire rig will be secured to shore using rope and/or steel cable, and latched to a hard structure or temporary t-post.

The method of placement and installation will: (1) ensure retrievability, (2) maximize effectiveness of the hydrophone detection area, (3) ensure the installation does not interfere with commercial or private boat traffic, and (4) is cryptic enough to avoid vandalism issues. Reclamation placed 14-20 hydrophones in 2017, and anticipates the placement of 20 to 40 hydrophones in 2019. Hydrophone placement in 2019 will likely occur in March and May in similar locations.

New Methods for 2018 and 2019

1.3.3 Tethering

Reclamation proposes to use a series of floating vertical tether lines to assess near-field release site predation rates at two SWP release sites (Curtis Landing and Horseshoe Bend) and two nearby control sites. Tethers will include a buoy marked with agency identification and contact information, and will be weighted with two 8-ounce weights, which will keep the line vertical. They will not anchor to the bottom of the river. The tether lines will be deployed for 4 days per month for 4 months (March through June), during the following schedule:

- March 19 – 22
- April 23 – 26
- May 21 – 24
- June 11 – 14

Tether lines will be baited hooklessly with either Golden Shiners (from a commercial bait supplier) or Chinook salmon (Mokelumne River Fish Hatchery). Bait fish will be delivered to Tracy Aquaculture Facility (available in March). Chinook salmon can be picked up anytime, likely in April or May. Fish will be delivered daily in two fish transport carboys from Tracy Aquaculture Facility to the Delta, and divided between boats equipped with a livewell to hold experimental fish. Once on site, crews will work to attach monofilament (2 to 4-pound breaking strength) loops through the mouth of each fish, and then to a snap swivel.

Because of concerns about independence of individual fish on tether lines from one another (i.e., if fish are too close together in space on a tether line, predation rates may be biased high because a single predator could sense and consume all tethered prey). Reclamation will look for differences in predation rates between:

a) a tether line baited with a single tethered fish, randomly placed low, medium, or high in the water column,
b) a tether line baited with three tethered fish, in low, medium, and high positions in the water column, and
c) a tether line baited with six tethered fish, distributed evenly through the water column.

One boat each will run tether lines at Curtis Landing release site, Curtis Landing control site, Horseshoe Bend release site, and Horseshoe Bend control site. Boats will stay at their respective site all day running a pre-determined number of tether lines. The order of tether types (1, 3, or 6 fish tethers) will be pre-determined according to a randomized number table. On single fish tether lines, tethered prey vertical position (low, medium, high) will also be randomized, with equal numbers of each depth type occurring daily.

Tethering sites:

- Curtis Landing Release Site: 38.032775, -121.737349
- Curtis Landing Control Site: 38.044985, -121.713470
- Horseshoe Bend Release Site: 38.080700, -121.730174
- Horseshoe Bend Control Site: 38.081443, -121.721277

At each site, tethers will be floated with the current via a set transect, one or more at a time, depending on ability of a single boat to maintain and catch them before entanglement with aquatic vegetation or other obstructions. Tethering lines will be deployed slightly up current of the release pipes (or start zone at control sites) and left to drift for a set number of minutes (determined during preliminary testing in March 2018). Maximum float times will be determined by the time it takes a tether to drift through the end-of-pipe zone during the strongest tidal condition. For example, if it takes a tether line 5 minutes to float through the end-of-pipe zone during the strongest outgoing tide, all tethers regardless of tidal condition will be fished for that amount of time. If a tether becomes tangled or for any other reason is retrieved prior to completing the full soak time, that data will be discarded and tether line re-deployed.

Data will be collected on start and end time of the tethering line float to calculate total fishing time (min:sec). Presence/absence of each tethered fish (and the position of that fish) will be recorded once the tethering line is removed from the water. Any prey fish missing will be deemed predation loss. Other water data (temperature, dissolved oxygen, pH, turbidity, and tidal condition) will be taken from the CDEC website closest to the tethering areas.

1.3.4 Hook and Line

Hook and line surveys will be conducted 1 day per month (total of 4 days March through June) to generate catch-per-unit-effort (CPUE) for predators (blackbasses, catfishes, striped bass, Sacramento pikeminnow) near the release sites. Intended size of predator catch is any of these species able to ingest a 100 mm or larger juvenile salmonid. All fish will be collected by hook and line from boat, using barbless hooks. Angling methods will target only large piscivores and will differ based on target species, but include commercially available cut bait (sardines, anchovies) placed on size 2 to 4 Gamakatsu circle hooks; artificial hard and plastic lures; and drift live bait (golden shiners). Length and weight of collected predators will be recorded. Data will be standardized by fish per unit of time fished.

1.3.5 Electrofishing

Reclamation proposes to use electrofishing to collect fish in the surrounding shoreline areas of the Curtis Landing and Horseshoe Bend release sites and nearby shoreline control sites, to determine species composition and relative abundance CPUE for each location. The goal of this sampling methodology is to compare predator assemblages and CPUE between the areas immediately surrounding the release sites, and off-site control areas. Reclamation will monitor for predator CPUE using electrofishing over a 4-month period (1 day per month) to look for changes in CPUE. Reclamation will electrofish for a total of 4 days in 2018 and 4 days in 2019.

Sampling will be performed using an electrofishing vessel (model SR-18EH) built by Smith-Root, Incorporated, configured with a 5.0 Generator Powered Pulsator (5.0 GPP) Electrofisher. This system is powered with a Smith-Root modified Honda generator with a rated output power of 5,000 watts and a direct current output peak of 1,000 volts. Current will be applied to the water using two Smith-Root anodes (model SAA-6), which have six stainless steel dropper cables that will be submerged to about 0.9 to 1.2 meters (3 to 4 feet) of water. Each anode is clipped to a boom arm on the vessel's port and starboard sides. The boom arms will be approximately 2 meters (6.5 feet) in length and pivoted 180 degrees, to allow the anodes to suspend directly in front of the bow. The boat's hull will perform as the cathode. Electrofisher controls will be mounted on the center console and the output will be controlled with footswitches on the deck at the bow. There is a counter on the center console that logs electrofishing time in seconds. A 250-liter (65-gallon) livewell will be positioned in the center of the boat to hold collected fish.

The electrofisher settings for current type, voltage range, amperage, pulses per second, and percent of selected pulse frequency will be selected prior to sampling and adjusted occasionally during sampling, as needed, by the boat operator. Direct current and low voltage range (50 to 500 VDC) will be used exclusively during this Project. Current will be maintained at 14 ± 1 amps.

Pulse per second will be set at 120 DC, with three exceptions when it will be set at 60 DC. Percent of range settings will vary between 20 and 45 percent. Total time spent electrofishing (shocking time) and total shocking distance will be recorded for each location at the completion of sampling. Distance will be calculated from waypoints taken with a handheld Global Positioning System (GPS) unit. Duration of the cumulative electric current will range from 1,000 to 8,000 seconds (17 to 133 minutes) and distance will range from 125 to 700 meters.

Electrofishing sites:

- Curtis Landing Release Site: 38.032775, -121.737349
- Curtis Landing Control Site: 38.044985, -121.713470
- Horseshoe Bend Release Site: 38.080700, -121.730174
- Horseshoe Bend Control Site: 38.081443, -121.721277

Electrofishing will coincide with the scheduled release of fish regardless of the tidal stage. Electrofishing sampling will occur at two release sites (Curtis Landing and Horseshoe Bend) and two nearby control sites, for a total of four sites. Sampling will occur 1 day per month, March through June (2018 and 2019). Four sampling events at each of four sites is 16 total electrofishing events each year.

Sampling will be constrained to an area that includes the littoral zone at each site. Sampling boundaries will included approximately 200 meters (656 feet) upstream and downstream on either side of the release pipes (release sites) or piling structures (control sites), for a total of 400 meters (1,312 feet) at each site. No greater than 6–meter (20–foot) sections of the shoreline will be sampled at any one time, due to the range of effectiveness of the electrofisher unit. Typically, each site will be sampled beginning at the upriver or downriver boundary (200 meters from release pipe or piling structure), depending on wind and current conditions. A GPS handheld receiver (iFinder Expedition C®, Lowrance, Tulsa, Oklahoma) will be used to describe the site locations.

GPS waypoints will be recorded at the beginning and ending of sampling to ensure consistency in maintaining site boundaries. All waypoint coordinates will be recorded in Universal Transverse Mercator (UTM) units.

Technicians will use the lowest possible settings to target fish, and will apply current for approximately 10 seconds, followed by 2 to 5-second intervals of no shocking. This process will be repeated several times per section depending on how quickly and how many fish surface. The technicians will use nets with long fiberglass handles to scoop stunned fish from the water. Netted fish will be deposited into the livewell for recovery. At the completion of sampling a location, all fish will be identified to species and enumerated. The fork lengths (FL) in millimeters of up to 20 fish of each species will be measured and recorded. Any captured ESA-listed fish will be released immediately and will not be deposited in the livewell.

Readings of water temperature, conductivity, dissolved oxygen, clarity, and depth along with wind speed, air temperature, tide, and time will be recorded at the beginning and ending of each sampling session. Water temperature (°C), conductivity (µS/cm), and dissolved oxygen (% and mg/L) will be measured using a multi-probe meter (YSI Models MPS 556 and 85, YSI Incorporated, Yellow Springs, Ohio). Water clarity will be measured in centimeters using a Secchi disc.

Water depth will be recorded in meters from the depth logger on the boat. Wind speed in kilometers per hour will be taken from http://cdec.water.ca.gov and air temperature (°C) will be taken from on www.wunderground.com. Tidal conditions will be observed in the field and confirmed from posted data at www.saltwatertides.com.

Similar species and numbers of fish are expected to be collected as Miranda *et al.* (2010) during electrofishing surveys (), since they performed a very similar electrofishing survey as the proposed action, although Miranda *et al.* had a higher level of effort. All fish, with the exception of dead listed (endangered or threatened) species, will be returned to the water. Though not anticipated, any listed species captured and deceased will be brought to the TFCF in Tracy, California, frozen and stored. NMFS, USFWS, and CDFW will be contacted if listed species are encountered dead and collected, and will be provided to the appropriate biologist, as necessary.

Reclamation anticipates encountering up to 10 winter- run and 10 spring run Chinook salmon each year, based on Miranda *et al.* (2010) survey results. During the Miranda *et al.* (2010) survey, the 13 Chinook salmon that were collected were juvenile adipose fin-clipped Chinook salmon, indicating that they were all hatchery fish, and none died due to electrofishing. The one steelhead that was collected was also adipose fin clipped. Sturgeon species are not expected to be encountered, as electrofishing surveys will target near-shore areas and is effective only at the top of the water column.

Table 2. Species collected by sampling date and sampling location during the 2007-2008 sampling period of a similar project and location (Miranda et al. 2010). CL = Curtis Landing release site, HS = Horseshoe Bend release site, C1 and C2 = control sites.

Sampling date	Sampling location	Black crappie	Bluegill	Brown bullhead	Carp	Chinook salmon	Delta smelt	Golden shiner	Goldfish	Hitch	Inland silverside	Largemouth bass	Red shiner	Redear sunfish	Sacramento blackfish	Sacramento pikeminnow	Sacramento sucker	Shimofuri goby	Smallmouth bass	Spotted bass	Steelhead	Striped bass	Threadfin shad	Tule perch	Warmouth	White catfish	Yellowfin goby
08/23/07	HS	2	9		1							20		5	33	11	4			1		8		10			
08/24/07	C1	1			2					3		10		2	1		8							7			
08/24/07	C2	3	4		2							22	1	4	8	3	5		1					9		2	
08/28/07	CL	1	2					3		2		18		7	1	3								14			
09/05/07	CL	1	3		1			5		5		13		11		2				1				17	1	1	
10/25/07	C1		6					1			1	17		21		1	7			3		3	6	5		1	1
10/25/07	C2	5	6		1			10		3	52	43		25	6	1	1			3			1	27			
10/26/07	HS	2						1			15	11		4	2	11						7	7	5			
10/29/07	CL	1						1		1		17		8										16		2	
12/13/07	C1		2					8		3	36	16		17		5	10							9			
12/13/07	C2	1	6	1				5			12	15		61	2		1							13			
12/14/07	HS	12	22					2		3	21	39		100	4	2								38			
12/21/07	CL		1								1	11		4		3	3							2			
02/19/08	CL	8	28		1			34	1	11	4	35		128		2					1			332	3		
02/20/08	HS	17	36			1		22		10	1	63		169	3	4								126	1		
02/26/08	C1		1			2		2				23		9		8								13			
02/26/08	C2	8	11			9		29		15		63		138	5	5		1						34	3		
03/26/08	C1		1		7							26		13		1	1					1		2			
03/26/08	C2	3	20		3		2	10		11		59		72	4	7	1	1				3		34			
03/27/08	CL	3	12					4		7	1	26		32		1								20			
03/28/08	HS	5	25		1	1		7		4		20		40		1								13	2		
	Total =	**73**	**195**	**1**	**19**	**13**	**2**	**144**	**1**	**78**	**144**	**567**	**1**	**870**	**69**	**71**	**41**	**2**	**1**	**8**	**1**	**22**	**14**	**746**	**10**	**6**	**1**

1.3.6 Conservation Measures

- Trammel nets, which were used in 2017 and posed a high risk to ESA-listed species, will not be used in 2018 or 2019.
- Fish sampling will be performed by Reclamation's qualified fish biologists.
- Only barbless hooks will be used during hook and line fishing from boat and angling methods will only target large piscivores, avoiding ESA-listed species.
- Tether lines will be baited hooklessly on single tether lines. There is no risk of entanglement with tether lines.
- Tethers will not be anchored to substrate.
- Dead or injured ESA-listed fish observed during electrofishing surveys will be reported immediately to NMFS, USFWS, and CDFW.

1.3.7 Interrelated and Interdependent Actions

When considering the direct and indirect effects of an action on a species or critical habitat, an action agency must also include the potential effects of other activities that are interrelated or interdependent with that action. "Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

Activities that are considered interrelated or interdependent to this Project would include the operations of the CVP and SWP fish salvage facilities, since were it not for those operations the Project would not be necessary. The routine handling, transport, and salvage of fish from these facilities may be impacted by the proposed Project (e.g., increased handling, delays, use of alternate release sites). The effects of studies at the CVP and SWP fish facilities were considered in a previous consultation (NMFS 2009).

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, each Federal agency must ensure that its 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 habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

Reclamation determined the proposed action is not likely to adversely affect winter-run, CV spring-run, CCV steelhead, or sDPS green sturgeon critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (2.12).

2.1 Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features.

In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

- Identify the rangewide status of the species and critical habitat expected 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 by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

In reviewing the information provided, NMFS had to make certain assumptions concerning the extent of the near-field and far-field effects and on the number of ESA-listed species likely to be present at the time of the proposed action. Information on fish presence in the action area is based on data (*e.g.*, CDFW and USFW trawl data) from various monitoring locations, fish salvage data, and recreational fishing reports (CDFW steelhead and sturgeon report cards).

2.2 Rangewide Status of the Species

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

2.2.1 Sacramento River Winter-run Chinook Salmon

- First listed as threatened (August 4, 1989, 54 FR 32085)
- Reclassified as endangered (January 4, 1994, 59 FR 440), reaffirmed as endangered (June 28, 2005, 70 FR 37160)

The Federally listed evolutionarily significant unit (ESU) of Sacramento River winter-run Chinook salmon (winter-run) occurs in the action area and may be affected by the proposed action. Detailed information regarding ESU listing, ESU life history, and viable salmonid population (VSP) parameters can be found in NMFS (2014).

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (NMFS 2011c). Since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively (California Department of Fish and Game 2012). However, from 2007 to 2011, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 (CDFG 2012). 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 rates (NMFS 2011c). In 2014 and 2015, the population was approximately 3,000 adults, slightly above the 2007–2012 average, but below the high (17,296) for the last 10 years (CDFG 1975–2016).

2014 and 2015 were the third and fourth years of a drought that resulted in increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the Red Bluff Diversion dam (RBDD) was approximately 5 and 4 percent, respectively (Williams *et al.* 2016). In 2015, egg-to-fry survival was the lowest on record (~4 percent) due to the lack of cold water in Shasta Reservoir during the fourth year of drought conditions. Adult returns were 1,546 in 2016 and 1,155 in 2017, as they were impacted by drought conditions on juveniles from brood years 2013 and 2014 (Williams *et al.* 2016).

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 Livingston Stone National Fish Hatchery (LSNFH) is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001-2010 average) compared to the estimated natural production that passes RBDD, which is 4.7 million per year based on the 2002-2010 average (Poytress and Carrillo 2011). Hatchery production typically represents approximately 3-4 percent of the total in-river juvenile winter-run production in any given year. However, in broodyear 2014 hatchery production from LSNFH was tripled (*i.e.*, 612,056 released) to offset the impact of the drought (SWRCB 2014). In 2014, hatchery production represented 83 percent of the total in-river juvenile production. In 2015, 420,000 hatchery winter-run were released. Due to these larger than average releases of hatchery fish, the winter-run population is composed of a considerably greater proportion of hatchery origin fish in recent years.

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 (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 weir). The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, which should restore spawning and rearing habitat for winter-run in Battle Creek and possibly establish an additional population 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, equivalent to 28,000 adult 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 the winter-run population lies within its spatial structure (NMFS 2011c). The winter-run ESU is comprised of only one population that spawns below Keswick Dam. 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) regulation of 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 2020. In 2018, the USFWS is in the process of releasing approximately 120,000 juvenile winter-run into Battle Creek to jump start the reintroduction. The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014).

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

2.2.1.1 Summary of the Sacramento River Winter-run Chinook Salmon ESU Viability

In summary, the extinction risk for the winter-run ESU has increased from moderate risk to high risk of extinction since 2005, and several listing factors have contributed to the recent decline, including drought and poor ocean conditions. Large-scale fish passage and habitat restoration actions are necessary for improving the winter-run ESU viability (Williams *et al.* 2016).

2.2.2 Central Valley Spring-run Chinook Salmon

- Listed as threatened (September 16, 1999, 64 FR 50394), reaffirmed (June 28, 2005, 70 FR 37160)

CV spring-run occur in the action area and may be affected by the proposed action. Detailed information regarding ESU listing, ESU life history, and VSP parameters can be found in NMFS (2014).

Historically, CV spring-run were the second most abundant salmon run in the Central Valley and one of the largest on the West Coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported a CV spring-run population as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of CV spring-run, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000-500,000 adults returning annually (CDFG 1990).

Monitoring of the Sacramento River during the time period that CV spring-run spawn indicates some spawning occurred from 1995–2009 in the mainstem upper portion of the river (CDFW 2016). Genetic introgression has likely occurred here due to lack of physical separation between spring-run and fall-run Chinook salmon populations (CDFG 1998).

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for CV spring-run. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance (NMFS 2011a, 2016b). The Feather River Fish Hatchery (FRFH) CV spring-run population represents an evolutionary legacy of populations that once spawned above Oroville Dam. The FRFH population is included in the ESU based on its genetic linkage to the natural spawning population, and the potential for development of a conservation strategy (June 28, 2005, 70 FR 37160).

The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CV spring-run, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (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). In the San Joaquin River basin, observations in the last decade suggest that spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2015).

CV spring-run is comprised of two known genetic complexes. Analysis of natural and hatchery CV spring-run stocks in the Central Valley indicates that the northern Sierra Nevada diversity group populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which is introgressed with fall-run (Good *et al.* 2005, Cavallo *et al.* 2011).

Because 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 in these watersheds (McElhany *et al.* 2000). Over the long term, these three remaining populations are considered to be vulnerable to anthropomorphic and naturally occurring catastrophic events. The viability assessment of CV spring-run population conducted during the status review (NMFS 2011a), found that the biological status of the ESU had worsened since the last status review (2005) and recommended that the species status be reassessed in 2 to 3 years as opposed to waiting another 5 years, if the decreasing trend continued. In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review (NMFS 2016b) found the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality reaching record lows. Returns in 2016 were improved but still low (6,453), indicating a continued unstable population and reason for concern (CDFW 2017). Since the effects of the 2012-2015 drought have not been fully realized, we anticipate at least several more years of very low returns, which may result in severe rates of decline (NMFS 2016b).

CV spring-run adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson *et al.* 2011). CV spring-run spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cold water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser *et al.* 2012).

2.2.2.1 Summary of the CV Spring-run ESU Viability

In summary, the extinction risk for CV spring-run remains at moderate risk of extinction (NMFS 2016b). Based on the severity of the drought and the low escapements as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (NMFS 2016b).

2.2.3 California Central Valley Steelhead

- Originally listed as threatened (March 19, 1998, 63 FR 13347); reaffirmed as threatened (January 5, 2006, 71 FR 834)

Steelhead from the CCV distinct population segment (DPS) occur in the action area and may be affected by the proposed action. Detailed information regarding DPS listing, DPS life history, and VSP parameters can be found in NMFS (2014).

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 CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Current abundance data for CCV steelhead are limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable because redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

CCV steelhead returns to Coleman National Fish Hatchery have increased over the last 4 years, 2011 to 2014 (NMFS 2016a). After hitting a low of only 790 fish in 2010, the last 2 years, 2013 and 2014, have averaged 2,895 fish. Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200–300 fish each year. Numbers of wild adults returning each year have ranged from 252 to 610 from 2010 to 2014.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 143 redds have been counted on the American River from 2002–2015 [data from Hannon *et al.* (2003), Hannon and Deason (2008), Chase (2010)]. An average of 178 redds have been counted in Clear Creek from 2001 to 2015 following the removal of Saeltzer Dam, which allowed steelhead access to additional spawning habitat. The Clear Creek redd count data ranges from 100-1023 and indicates an upward trend in abundance since 2006 (USFWS 2015a).

The returns of CCV steelhead to the FRFH experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively. In recent years, however, returns have experienced an increase with 830, 1797, and 1505 fish returning in 2012, 2013, and 2014, respectively (NMFS 2016a). Overall, CCV steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present.

An estimated 100,000 to 300,000 naturally produced juvenile CCV steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the USFWS Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 CCV steelhead smolts are produced naturally each year in the Central Valley. Trawl data indicate that the level of natural production of CCV steelhead has remained very low since the 2011 status review, suggesting a decline in natural production based on consistent hatchery releases (NMFS 2011b). Catches of CCV steelhead at the fish collection facilities in the southern Delta are another source of information on the production of wild steelhead relative to hatchery steelhead (CDFW data: ftp.delta.dfg.ca.gov/salvage). The overall catch of CCV steelhead has declined dramatically since the early 2000s, with an overall average of 2,705 in the last 10 years. The percentage of wild (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999.

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). 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. CCV steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, National Marine Fisheries Service 2016a). Most of the CCV steelhead populations in the Central Valley have a high hatchery component, including Battle Creek, the American River, Feather River, and Mokelumne River.

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley *et al.* 2006). Recent reductions in population size are supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams as summer-run have been extirpated (McEwan and Jackson 1996, Moyle 2002).

Although CCV steelhead will experience similar effects of climate change to Chinook salmon in the Central Valley, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 14°C to 19°C (57°F to 66°F). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough *et al*. 2001). In fact, McCullough *et al*. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild CCV steelhead populations.

2.2.3.1 Summary of California Central Valley Steelhead DPS Viability

Natural CCV steelhead populations continue to decrease in abundance and the proportion of natural fish compared to hatchery fish has declined over the past 25 years (Good *et al.* 2005, 2016a). The long-term abundance trend remains negative. Hatchery production and returns dominant this ESU. Most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish.

In summary, the status of the CCV steelhead DPS appears to have remained unchanged since the 2011 status review, and the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016a).

2.2.4 Southern Distinct Population Segment (sDPS) of North American Green Sturgeon

- Listed as threatened (April 7, 2006, 71 FR 17757)

The Federally listed sDPS green sturgeon occurs in the action area and may be affected by the proposed action. Detailed information regarding DPS listing, DPS life history, and VSP parameters can be found in the 5-Year Status Review (NMFS 2015).

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During late summer and early fall, subadults and non-spawning adult green sturgeon can frequently be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991, Moser and Lindley 2006). Using polyploid microsatellite data, Israel *et al.* (2009) found that green sturgeon within the Central Valley of California belong to the sDPS.

Additionally, results of acoustic tagging studies have found that green sturgeon spawning within the Sacramento River are exclusively sDPS green sturgeon (Lindley *et al.* 2011). In California, sDPS green sturgeon are known to range throughout the estuary and the Delta and up the Sacramento, Feather, and Yuba rivers (Israel *et al.* 2009, Cramer Fish Sciences 2011, Seesholtz *et al.* 2014). It is unlikely that green sturgeon utilize areas of the San Joaquin River upriver of the Delta with regularity, and spawning events are thought to be limited to the upper Sacramento River and its tributaries. There is no known modern usage of the upper San Joaquin River by green sturgeon, and adult spawning has not been documented there (Jackson and Eenennaam 2013).

Recent research indicates that sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River and also breeds opportunistically in the Feather River and possibly even the Yuba River (Cramer Fish Sciences 2011, Seesholtz *et al.* 2014). Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent, but unconfirmed, extirpation of spawning populations from the San Joaquin River narrows the available habitat within their range, offering fewer habitat alternatives. Whether sDPS green sturgeon display diverse phenotypic traits such as ocean behavior, age at maturity, and fecundity, or if there is sufficient diversity to buffer against long-term extinction risk is not well understood. It is likely that the diversity of sDPS green sturgeon is low, given recent abundance estimates (NMFS 2015).

Trends in abundance of sDPS green sturgeon have been estimated from two long-term data sources: (1) salvage numbers at the State and Federal pumping facilities (see below), and (2) by incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Historical estimates from these sources are likely unreliable because the sDPS was likely not taken into account in incidental catch data, and salvage does not capture range-wide abundance in all water year types. A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities, the Skinner Delta Fish Protection Facility (SDFPF), and the TFCF. These data should be interpreted with some caution. Operations and practices at the facilities have changed over the decades, which may affect salvage data. These data likely indicate a high production year vs. a low production year qualitatively, but cannot be used to rigorously quantify abundance.

Since 2010, more robust estimates of sDPS green sturgeon have been generated (Israel *et al.* 2010). As part of a doctoral thesis at UC Davis, Ethan Mora has been using acoustic telemetry to locate green sturgeon in the Sacramento River, and to derive an adult spawner abundance estimate (Mora *et al.* 2014). Preliminary results of these surveys estimate an average annual spawning run of 223 (DIDSON) and 236 (telemetry) fish. This estimate does not include the number of spawning adults in the lower Feather or Yuba Rivers, where green sturgeon spawning was recently confirmed (Seesholtz *et al.* 2014).

The parameters of green sturgeon population growth rate and carrying capacity in the Sacramento Basin are poorly understood. Larval count data shows enormous variance among sampling years. In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events NMFS (2010b). Other indicators of productivity such as data for cohort replacement ratios and spawner abundance trends are not currently available for sDPS green sturgeon.

Southern DPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. The Anderson-Cottonwood Irrigation District Diversion Dam (ACID) is considered the upriver extent of green sturgeon passage in the Sacramento River (71 FR 17757, April 7, 2006). However, Mora (2014) found the upriver extent of green sturgeon spawning is approximately 30 kilometers downriver of ACID where water temperature is higher than ACID during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID may remain within tolerable levels for the embryonic and larval life stages of green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of green sturgeon in other accessible habitats in the Central Valley (*i.e.*, the Feather River) is limited, in part, by late spring and summer water temperatures (NMFS 2015). Similar to salmonids in the Central Valley, green sturgeon spawning in tributaries to the Sacramento River is likely to be further limited if water temperatures increase and higher elevation habitats remain inaccessible.

2.2.4.1 Summary of Green Sturgeon sDPS Viability

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate (NMFS 2010a). Although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2010a). Lindley *et al.* (2008), in discussing winter-run, states that an ESU (or DPS) represented by a single population at moderate risk of extinction is at high risk of extinction over a large timescale; this would apply to the sDPS for green sturgeon. The most recent 5-year status review for sDPS green sturgeon found that some threats to the species have recently been eliminated, such as take from commercial fisheries and removal of some passage barriers (NMFS 2015). However, since many of the threats cited in the original listing still exist, the threatened status of the DPS is still applicable (NMFS 2015).

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area includes the waters surrounding the 200 meters upstream and 200 meters downstream of the Curtis Landing release site on the San Joaquin River and Horseshoe Bend release site on the Sacramento River (**Figure 3**), as well as two nearby control sites. The action area also includes locations where acoustic arrays may be placed around Sherman Island sites in 2019, for a distance of 200 meters in front of each release site on the Sacramento River. In addition, the Project will utilize the TFCF located in the southern portion of the Delta on Old River. Tagged fish will be transported by tanker trucks along State Highway 4 through Brentwood and over the Highway 160 Bridge to Sherman Island release sites. The aquatic habitat in the action area is representative of the estuarine transition zone, where freshwater from the Delta mixes with saline water from San Francisco Bay to the west.

Figure 3. Map of the action area showing locations of SWP release sites and control sites.

Winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon have the potential to occur in the action area during the proposed Project periods from March through June in 2018 and 2019.

2.4 Environmental Baseline

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

The Project is located in the northwestern portion of the Sacramento-San Joaquin Delta at the confluence of the Sacramento and San Joaquin rivers, an area commonly referred to as the western Delta (**Figure 3**).

The principal water bodies near the action area include the Sacramento River and the San Joaquin River. These water bodies are tidally influenced. Habitats in the action area consist of deep water ship channels and subtidal and intertidal habitats. Salinities in the action area can range from 0.2 to 0.5 parts per thousand (ppt). The salinity is managed by the State and Federal water projects[1] on the low side (0.2 ppt) to prevent saltwater intrusion into the Delta and degrading irrigation for agriculture, as well as municipal water supplies.

The land within the action area consist of irrigated fields traversed by irrigation and drainage ditches. These canals and ditches seasonally flood and drain pastures with Delta water that is either pumped or siphoned from the Sacramento and San Joaquin rivers. The CVP and SWP release sites on Sherman Island are located on levees that separate and protect the site from the waters of the Delta. These existing levees were built in the late 1800s and are maintained for agricultural purposes by Reclamation District 341.

The Delta region, where the Project is located, historically supported a healthy aquatic ecosystem, but its habitat value for ESA-listed species is considered greatly reduced from historic conditions. Since the 1850s, wetland reclamation for urban and agricultural development has caused the cumulative loss of 96 percent of seasonal wetlands and 94-98 percent of riparian forests in the Central Valley (Whipple *et al.* 2012). Several factors are thought to contribute to the decline in the health of the habitat including: entrainment into the south Delta SWP and CVP pumping facilities, reverse flows, maintenance dredging in the ship channels, and increased predation by nonnative predator species (*e.g.*, striped bass and largemouth bass) (Baxter *et al*. 2007). The increase in the abundance of largemouth bass, as shown by the salvage data at the CVP and SWP pumps, occurred at the same time as the increase in the range of the invasive submerged macrophyte *Egeria densa* (Brown and Michniuk 2007).

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[1] The CVP and SWP manage salinity in the Delta pursuant to the State Water Resource Control Board Decision 1641 requirements.

In the central Delta region, low-salinity water management, invasive aquatic plants (*E. densa*), and other factors have resulted in increased numbers of nonnative predators, most important of which are striped bass and largemouth bass. Nobriga and Feyrer (2007) report that largemouth bass have a more limited distribution in the Delta than striped bass, although their impact on prey species, such as juvenile salmonids, is higher. The proliferation of *E. densa* provides habitat for largemouth bass as well as their prey, and its rapid expansion in the Delta increased more than 10 percent per year from 2004 to 2006 (Baxter *et al.* 2007). Although Chinook salmon fry are often found in the central Delta and make use of the dense stands of *E. densa* for habitat, Brown (2003) found that survival is lower for fry rearing in the central Delta than those rearing in tributary streams. Those fry that migrate through the central Delta rather than directly through the Sacramento or San Joaquin River also have a lower survival rate (Brown 2003).

Aside from increasing the habitat area for predators, the proliferation of *E. densa* and water hyacinth (*Eichhornia crassipes*) may have other negative impacts on ESA-listed species. It can overwhelm littoral habitats where salmonids and sDPS green sturgeon rear, and it also appears to contribute to the recent reduction in turbidity of the central and south Delta regions by reducing flow velocity (Brown 2003) and mechanically filtering the water column (Nobriga *et al.* 2005). The resulting increased water clarity has negative effects on juvenile salmonids by increasing their susceptibility to predation. The U.S. Department of Agriculture and California Division of Boating and Waterways have an active program to control aquatic invasive plant species in the Delta using a variety of treatment methods.

2017 Pilot Study Activities

Methods used during the 2017 pilot study included trammel nets, which target larger fish because of the small mesh of the internal wall and the larger mesh of the external walls. Trammel nets were paired with DIDSON cameras to determine species-specific predator abundance at the release pipes within 8-hour periods following release events and fished for an 8-hour period. Although no ESA-listed species were caught during 2017, trammel nets had the potential to catch any adult fish. A small number of predators caught in the trammel nets (approximately 5 of each species) were sacrificed after gastric lavage for quality assurance/quality control to verify lavage efficiency. Fishes that displayed poor resuscitation or were in poor condition after handling were targeted for sacrificing. All other predators were released and received fin clips and/or passive integrative transponder (PIT) tags to monitor site fidelity. PIT tagging and gastric lavage of predators was not likely to have any impact on ESA-listed fish since the predators would not be in contact with wild or hatchery ESA-listed fish after they were removed from the nets.

Hatchery-raised juvenile Chinook salmon were photonically marked with a fluorescent paint that can be applied with a pressurized injection system under the skin. The mark can then be detected later with the aid of fluorescent lights. Photonically marked fish were released through the release site pipe (200 fish per release) to detect diet samples of captured predators. Results were extrapolated to total abundance of predators to estimate predator loss. Photonic marks have been used on salmon, trout, Delta smelt, largemouth bass (*Micropterus salmoides)* and striped bass (*Morone saxatilis)* without any negative response from the marking or differences in predation rates (Hayes *et al.* 2000, Catalano *et al.* 2001, Mohler *et al.* 2002, U.S. Bureau of Reclamation 2008, Castillo *et al.* 2014).

Trammel nets and phontonically marking fish will not be used in 2018 and 2019 sampling methods.

Other methods used during the 2017 pilot study, which may continue to be used in 2018 and 2019 include the use of a DIDSON camera (connected to boat for mobile monitoring), and acoustic arrays and release of acoustic-tagged fish potentially in 2019. Twenty to 40 hydrophones may be used in 2019 around sites at Sherman Island to detect acoustic-tagged fish released with salvaged fish at SWP/CVP release sites. 2017 hydrophone locations included Sherman Island sites as well as at Rio Vista (6 miles upstream Sacramento River). 2019 locations will not include the Rio Vista location.

2.4.1 Status of the Species within the Action Area (March 1 through June 30)

The action area functions primarily as a migratory corridor for winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon. In addition, it also provides some use as holding and rearing habitat for each of these species. Juvenile salmonids may use the area for rearing for several months during the winter and spring. Green sturgeon use the area for rearing and migration year-round. Adult winter-run typically migrate through the estuary/Delta between November and June with the peak occurring in March (**Table 3**). Adult CV spring-run migrate through the Delta from January to June (**Table 4**). Adult CCV steelhead migration typically begins in August and extends through the winter to as late as May (**Table 5**), and adult green sturgeon start to migrate upstream in February and can extend into July (**Table 6**). Generally, juveniles migrate downstream in the winter and spring.

2.4.1.1. Winter-run Chinook salmon

Adult winter-run are expected to be in the action area in March, April, and May (**Table 3**) as they migrate upstream to spawn in the upper Sacramento River. Since the action area is a transition zone between salt and freshwater at the confluence of the Sacramento and San Joaquin rivers, adult salmon sometimes wander through the Delta searching for specific scents that lead them to their natal spawning area. Winter-run adults have been known to stray into the San Joaquin River and around the Delta islands as they make their way through the maze of channels (CDFW 2016). Juvenile winter-run occur in the Delta primarily from November through early May, using length-at-date criteria from trawl data in the Sacramento River at West Sacramento (USFWS 2012). A review of fish monitoring data from 2009 to 2013 in and around Sherman Island showed low juvenile winter-run numbers present in April and none in May (USFWS 2015b).

Table 3. Temporal occurrence of winter-run in the Delta.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult WR[1]	MED	HIGH	HIGH	HIGH	MED	MED	NONE	NONE	NONE	NONE	MED	MED
Juvenile WR[2]	LOW	MED	HIGH	MED	NONE	NONE	NONE	NONE	NONE	LOW	LOW	MED
Salvaged WR[3]	MED	HIGH	HIGH	LOW	LOW	LOW	NONE	NONE	NONE	NONE	NONE	LOW

HIGH MED LOW NONE

[1]Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).

[2]Juvenile presence in the Delta was determined using DJFMP data (USFWS 2016).

[3]Months in which salvage of wild juvenile winter-run at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (NMFS 2016c).

2.4.1.2 CV Spring-run Chinook salmon

Adult CV spring-run are expected to be migrating upstream through the action area primarily in February to April (**Table 4**). As with winter-run, adult CV spring-run are expected to be migrating through the action area during the proposed action. Adult CV spring-run could stray around Sherman Island and be affected by Project activities. According to trawl and seine data in the Delta, juvenile CV spring-run may be present in the action area during Project surveys in March to May (USFWS 2016).

Table 4. Temporal occurrence of CV spring-run in the Delta.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SR[1]	MED	HIGH	HIGH	HIGH	MED	MED	NONE	NONE	NONE	NONE	NONE	NONE
Juvenile SR[2]	LOW	LOW	LOW	HIGH	MED	NONE	NONE	NONE	NONE	NONE	NONE	LOW
Salvaged SR[3]	LOW	LOW	MED	HIGH	MED	NONE	NONE	NONE	NONE	NONE	NONE	NONE

HIGH MED LOW NONE

[1]Adults enter the Bay late January to early February (CDFW 1998) and enter the Sacramento River in March (Yoshiyama *et al.* 1998). Adults travel to tributaries as late as July (Lindley *et al.* 2004). Spawning occurs September to October (Moyle 2002).

[2]Juvenile presence in the Delta based on DJFMP data (USFWS 2016).

[3]Juvenile presence in the Delta based on salvage data (NMFS 2016c).

2.4.1.3 CCV Steelhead

Adult steelhead enter freshwater in August (Moyle 2002) and peak migration of adults move upriver in late September (Hallock et al. 1957). Adult steelhead will hold until flows are high enough in the tributaries to migrate upstream where they will spawn from December to April (Hallock et al. 1961). Unlike salmon, not all steelhead die after spawning. A small percentage (typically females) migrate back downstream from the tributaries and reach the Sacramento River during March and April, and have a high presence in the Delta in May. These adult steelhead (kelts) migrating downstream are in poor condition and less likely to avoid the electric field of the electrofisher (Teo *et al.* 2011). Data on the frequency of occurrence and downstream run timing of steelhead kelts in the Delta are very limited.

CCV steelhead juveniles (smolts) can start to appear in the action area as early as October, based on the data from the Chipps Island trawl (USFWS 2016) and CVP/SWP Fish Salvage Facilities (CDFW 2016). In the Sacramento River, juvenile CCV steelhead generally migrate to the ocean in spring and early summer at 1 to 3 years of age and 100 to 250 mm FL, with peak migration through the Delta in March and April (Reynolds *et al.* 1993).

CCV steelhead presence in CVP/SWP Fish Salvage Facilities increases from November through January (21.6 percent of average annual salvage) and peaks in February (37.0 percent) and March (31.1 percent) before rapidly declining in April (7.7 percent). By June, emigration essentially ends (**Table 5**), with only a small number of fish being salvaged through the summer at the CVP/SWP Fish Salvage Facilities. Kodiak trawls conducted by the USFWS and CDFW on the mainstem of the San Joaquin River downstream at Mossdale (upstream of Stockton) routinely catch low numbers of CCV steelhead smolts from March to the beginning of June (CDFW 2013). The rotary screw trap (RST) monitoring on the Stanislaus River at Caswell State Park and further upriver near the City of Oakdale indicate that smolt-sized steelhead start emigrating downstream in January and continue through late May. Fry-sized *O. mykiss* (*i.e.*, 30 to 50 mm) are captured at the Oakdale RST on the Stanislaus River starting as early as April and continuing through June (FishBio 2012).

Table 5. Temporal occurrence of CCV steelhead in the Delta.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SH[1]	MED	MED	MED	MED	HIGH	NONE	NONE	MED	HIGH	MED	MED	MED
Juvenile SH[2]	LOW	MED	MED	HIGH	HIGH	LOW	LOW	NONE	LOW	NONE	NONE	LOW
Salvaged SH[3]	MED	HIGH	HIGH	MED	LOW	LOW	NONE	NONE	NONE	NONE	LOW	LOW

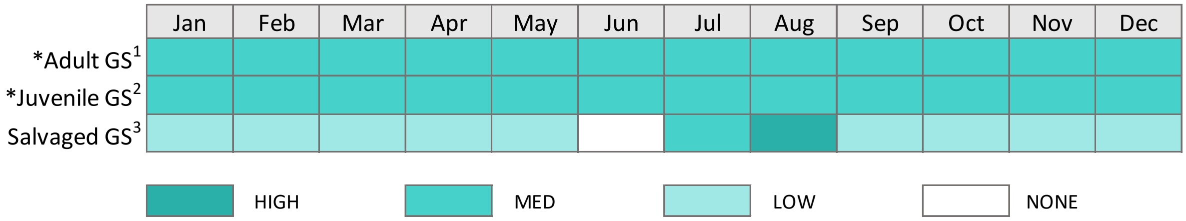
HIGH MED LOW NONE

[1]Adult presence was determined using information in (Moyle 2002), (Hallock *et al.* 1961), and (CDFG 2007).
[2]Juvenile presence in the Delta was determined using DJFMP data (USFWS 2016).
[3]Months in which salvage of wild juvenile steelhead at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (NMFS 2016c).

2.4.1.4 Southern DPS of North American Green Sturgeon

For sDPS green sturgeon, the action area functions as migratory, holding, and rearing habitat for adults, subadults, and juveniles, since their presence is considered year-round in the Delta. Juvenile green sturgeon have been collected at the CVP/SWP South Delta Fish Facilities throughout the year (**Table 6**). Green sturgeon numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981–2015, green sturgeon may be present during any month of the year, but only a few juveniles have been observed since 2011. The average size of salvaged green sturgeon is 330 mm (range 136 mm–774 mm). The size range indicates that these are sub-adults rather than adult or larval/juvenile fish. These sub-adult fish likely utilize the Delta for rearing for a period of up to approximately 3 years. Observations of sport caught green sturgeon in the San Joaquin River indicate that sub-adult green sturgeon have a potential to be present within the action area during the March through May field season (CDFW 2011, 2014a; Beccio 2017). It is likely that their population density would be low within the action area. However, it is difficult to draw conclusions from the lack of observations in the monitoring data, since green sturgeon are benthic species and are not typically caught in surface-oriented gear like trawls and seines.

Table 6. Temporal occurrence of sDPS green sturgeon in the Delta.



[1]Adult presence was determined to be year round according to information in CDFW (2014), Lindley and Moser (2008), and Moyle (2002).

[2]Juvenile presence in the Delta was determined to be year round by using information in CDFW DJFMP data, Moyle et al. (1995) and Radtke (1966).

[3]Months in which salvage of green sturgeon at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (1981-2012 CDFG daily salvage data).

*Not enough catch data to determine percent presence by month for adults or juveniles, except for salvaged green sturgeon.

2.4.2 Effects of Global Climate Change in the Action Area

The world is about 1.3°F warmer today than a century ago. The latest computer models predict that without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (IPCC 2001). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data, Huang and Liu (2000) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 meters to 1.0 meters along the Pacific coast in the next century (Reclamation 2014), mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (e.g., estuarine, riverine, mud flats) in the Delta. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, which will directly impact salmonids and green sturgeon during their migration through the Delta (e.g., warmer temperatures, turbidity) and would also affect their spawning success upstream.

Droughts along the West Coast and in the interior Central Valley of California are already occurring and are likely to increase with climate change. This means decreased groundwater storage and stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water declines, while pollution, acidity, and salinity levels may increase. Warmer stream temperatures will allow for invasive species to overtake native fish species and impact predator-prey relationships (Peterson and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2°C and 7°C (3.6°F and 12.6°F) by the year 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Reclamation 2014) with a drier hydrology predominated by precipitation rather than snowfall. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Hayhoe *et al.* 2004). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. Summer temperatures and flow levels will likely become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. Without the necessary cold water pool from snow melt, water temperatures could potentially rise above thermal tolerances for salmonids that must spawn and rear below reservoirs in the summer and fall.

From 2012 to 2015, California experienced one of the worst droughts in the last 83 years. The winter-run population experienced lower egg and juvenile survival due to poor freshwater conditions (e.g., low flows, higher temperatures) caused by the drought. Adult abundance of other listed salmonids and green sturgeon is expected to decline significantly in the next year or two, given the poor river conditions since 2012.

2.5 Effects of the Action

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

The approach used for this analysis was to identify which ESA-listed species would be likely to be present in the action area from March through June (**Table 7**). NMFS conducted a review of nearby CDFW monitoring locations, run timing, and fish salvage data to determine the likelihood of ESA-listed fish presence. Adult salmonids typically migrate through the Delta within a few days. Juvenile Chinook salmon spend from 3 days to 3 months rearing and migrating through the Delta to the mouth of San Francisco Bay (Brandes and McLain 2001, MacFarlane and Norton 2002)

Table 7. Presence of ESA-listed species in the action area (NMFS 2016a,b; CDFW 2016). For CCV steelhead, presence includes kelts migrating downstream after spawning.

Timing	**March**		**April**		**May**		**June**	
Species-Life Stage	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles
Winter-run	Yes	Yes	Yes	Yes	Yes	No	Yes	No
CV spring-run	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
CCV steelhead	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
sDPS green sturgeon	Year-round		Year-round		Year-round		Year-round	

2.5.1 DIDSON Camera

DIDSON cameras transmit sound pulses and convert the returning echoes into digital images, much like a medical ultrasound sonogram. These cameras utilize high frequency sound waves to “see,” via echolocation, at night or in turbid waters to identify large targets (e.g., predators). The DIDSON camera is typically mounted either stationary or from a boat on a long pole that extends underwater. DIDSON has been used extensively to estimate abundances of migratory fishes (mostly salmon) with relatively high accuracy (Holmes *et al.* 2006); to remotely measure fish swimming past the camera (Burwen *et al.* 2011); and to study fish behavior under a variety of conditions (Mueller *et al.* 2006, Boswell *et al.* 2008). In addition, DIDSON cameras have been used to quantify predation-related behavior in offshore environments (Price *et al.* 2013).

Most fishes hear in the range of 100–1,000 Hertz (Hz). Fish that are hearing generalists, which include salmonids, have a hearing range of 1,000–1,500 Hz (Popper and Hastings 2009). Rainbow trout (*O. mykiss*) hear at 600 Hz. For sturgeon, data on hearing are sparse, however, (Popper 2005) suggests sturgeon hear in the range of 100–1,000 Hz. DIDSON and ARIS cameras operate at 1.8–3.0 million Hz (MHz), which is quite above the hearing threshold for fish. Most fish, including salmonids and sturgeon, cannot feel sound pulses in the MHz range (Popper and Hastings 2009). Therefore, use of DIDSON camera technology for underwater observations around the release sites is not likely to cause any negative response to ESA-listed fish species. Underwater camera work is passive, non-obtrusive, and is not expected to harm fish released from the salvage facilities or any fish in the action area.

2.5.2 Acoustic Arrays (Hydrophones/Receivers)

In a supplemental letter received on February 13, 2017, Reclamation described plans to deploy VEMCO hydrophones at 6 sites in the action area in 2017 (**Figure 3**), and 5 sites in 2018 and 2019 (excluding the Rio Vista location). Each of the hydrophones will be attached to a rope, which is anchored to the bottom using either a cinder block (16 inches x 8 inches x 8 inches) or a custom built tripod. Ropes, steel cables, and buoys will secure the hydrophones to the shore. To secure to the shore, T-posts or large rocks will be used to tie the cable or ropes around. The anchors 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 anchors by a buoy below the water surface to avoid boat traffic and public view. Stationary hydrophones (VEMCO HR2s), a hydrophone array (VEMCO VR2Ws), and a mobile boat-mounted hydrophone (VEMCO VR100) will be use to track the acoustic tags. Special predator-detection tags will be used to track juvenile hatchery fish as they exit the release pipe. Reclamation proposes to deploy 20-40 hydrophones in 2019 (14-20 hydrophones were deployed in the 2017 pilot study). The removal process will be similar to the deployment described above. Based on experience with other projects, any noise associated with the installation or removal should be short-term and not rise to the level where it produces acoustic noise that would result in acute or long-term cumulative injuries to exposed fish.

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 acoustic tags (180 KHz) is above the upper threshold for hearing in the fish species of interest (100–1,000 Hz for salmonids and sturgeon) and therefore is not expected to affect any ESA-listed fish in the action area that are exposed to the emitted signals from the acoustic tags, either physically or behaviorally.

2.5.3 Tethering

Tethering is widely used in fisheries to determine predation rates of an area. Tethering will be conducted 4 days per month, March through June. Bait fish used for the Project will be golden shiners from a commercial bait supplier or experimental Chinook salmon from the Mokelumne River Fish Hatchery (delivered to the Tracy Aquaculture Facility for pick up). Fish will be hauled to the Delta and placed in the livewells of two boats, where crews will work to attach monofilament (2 to 4-lb breaking strength) loops through the mouth of each fish, and then to a snap swivel. Tethered fish will be stored in a 5-gallon bucket until attachment to a tethering line.

The tether lines will be attached to a buoy, and weighted with two 8-ounce weights to keep the line vertical. Weights will not be anchored to the bottom, but may bounce along the bottom while drifting downstream past the release site (or control site). The tether lines are hookless. Bait fish are attached to monofilament fishing line. When the tether lines are retrieved at the end of sampling, remaining bait fish are counted. However many bait fish are missing are presumed to have been consumed by predators. If any adult salmonids or green sturgeon do consume the bait fish, there is no risk of injury since the tethers are hookless. Deployed tethers will be closely monitored and any entanglements will be sorted out immediately, leaving no fouled gear in the river. If listed species do encounter the tether lines, there is no risk of entanglement for them and they are free to pass by unharmed. Since tether lines are hookless and gear will be closely monitored for entanglement, impacts from tethering are not expected to harm any fish in the action area.

2.5.4 Hook and Line

Hook and line surveys from boat will occur 1 day per month for 4 months (total of 4 days) in order to generate CPUE for blackbasses, catfishes, striped bass, and Sacramento pikeminnow near the four release and control sites. All hooks will be barbless. This sampling method is similar to daily recreational fishing that occurs throughout the Delta year-round. However, Reclamation will use specific angling techniques, including Gamakatsu circle hooks, hard and plastic lures, and drifting live bait (golden shiners), that are intended to catch large piscivores (predominately blackbasses, catfishes, striped bass, and Sacramento pikeminnow), and are not likely to catch migratory salmonids or green sturgeon. Salmonids are typically targeted with angling methods different than those Reclamation proposes to use. Sturgeon angling is done with specialized methods that will not be used.

Communications with bait shops and recreational anglers confirmed that the proposed techniques will target only large piscivore predators, and will not target adult ESA-listed salmonids or green sturgeon. Overall, any impacts of hook and line surveys for predator CPUE around the release sites and control sites are discountable to any ESA-listed fish species in the action area.

2.5.5 Electrofishing

Electrofishing surveys are an effective fisheries management tool for assessing species composition and abundance (FishBio 2010). An electrofishing boat is mounted with a generator that applies electrical currents that pass through the water from a positive (anode) to a negative electrode (cathode). Fish muscles are controlled by electrical signals sent through the nervous system from the brain. The negatively charged brain is believed to be attracted to the positively charged anode. The electrical current interrupts the neurological pathway causing the fish to involuntary swim toward the anode, and causes the muscles to contract, temporarily impairing the fish. It is important that the electrofisher operator is well trained, since if the electrical output is too strong, the force of the muscle contractions can cause spinal injuries to the fish (FishBio 2010).

Water chemistry can affect the strength of the electrical current. If water conductivity is elevated, then the voltage should be reduced, to prevent an electrical output that is too high, in order to prevent injury to fish. Generally, each electrofishing session should start with all settings (voltage, pulse width, and pulse rate) set to the minimums needed to capture fish (NMFS 2000). These settings should be gradually increased only to the point where fish are immobilized and captured. The peak power needed to immobilize a fish decreases as the volume of a fish increases (Dolan and Miranda 2003). In other words, the larger the fish, the less electrical output is needed. Once a fish is immobilized, it can then be collected at the surface with a net and handled with little stress or injury. Generally, fish are immobilized for a few seconds to a few minutes (FFWCC)].

Reclamation proposes to use a 5.0 GPP electrofishing boat at the surrounding shorelines of the four Project locations (Curtis Landing release site, Horseshoe Bend release site, and 2 control sites, **Figure 3**) for 1 day per month for 4 months each year (2018 and 2019), a total of 16 events each year. A total of 400 meters (200 meters upriver and 200 meters downriver of each site) will be sampled. No greater than 6-meter (20-foot) sections of the shoreline will be sampled at any one time, due to the range of effectiveness of the electrofisher unit.

Six stainless steel dropper cables will hang from the front of the boat (three on the port and three on the starboard) to act as the anodes, while the boat's hull will act as the cathode. Current will be applied for approximately 10 seconds, followed by 2- to 5-second intervals of no current, and repeated several times per section depending on how quickly and how many fish surface. Shocking time will range from 1,000 to 8,000 seconds (17 to 133 minutes). Only direct current and a low voltage range of 50 to 500 volts (VDC) will be used. Electrofisher settings will occasionally be adjusted by the operator as needed. Crew will net the stunned fish and deposit them into the livewell for recovery. At the completion of sampling each location, all fish in the livewell will be identified to species and enumerated. The fork length of up to 20 fish of each species will be measured. If any ESA-listed fish are encountered during electrofishing, they will be immediately returned to the water and will not be deposited into the livewell.

This Project is very similar to the Miranda *et al.* (2010) study, in which they used the same electrofisher boat to conduct 21 electrofishing surveys at the Curtis Landing and Horseshoe Bend release sites and two control sites in August 2007 through March 2008. During this study, they collected 26 difference species and a total of 3,100 fish. Of these fish, one was a hatchery steelhead (259 mm FL) and 13 were hatchery Chinook salmon (45 to 69 mm FL). No ESA-listed fish were collected. Although the Miranda *et al.* (2010) study had a higher level of effort, since the Miranda study occurred during different months, the March results would be the most relevant, where one of the 13 hatchery Chinook salmon was collected on March 28, 2008. Therefore, NMFS assumes Reclamation will collect similar species and numbers of fish as the March results in **Table 2**.

Electrofishing causes fish to be temporarily immobilized, or if electrical currents are too strong, can cause spinal injury, leading to mortality. Smaller fish may feel the effects of the electrical current, but it may be too weak to cause immobilization; these fish would likely not be observed. Any fish that are immobilized due to electrofishing, will typically recover after a few seconds to a few minutes (FFWCC). All four ESA-listed species may be present in the action area during any of the 16 electrofishing events, and therefore may be susceptible to electrofishing, although it is unlikely that juvenile winter-run, juvenile CV spring-run, and adult CCV steelhead will be present towards the end of the sampling season due to their migration timing (**Table 7**). Adult winter-run are less likely to be present near the Curtis Landing sites, however they have been known to stray into the San Joaquin River. It is unlikely that any sturgeon species will be encountered, since electrofishing surveys will target nearshore areas, and it is effective only at the top of the water column. However, since larger fish are more affected by this sampling method, any sDPS green sturgeon close enough to the electrofishing boat during the surveys would have a greater chance of being injured or killed.

During the proposed action, all fish, with the exception of dead ESA-listed species, will be returned to the water. Though not anticipated, any ESA-listed species captured and deceased will be brought to the Tracy Fish Collection Facility in Tracy, California, frozen and stored, and CDFW, NMFS, and the USFWS will be contacted.

2.6 Cumulative Effects

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

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

2.6.1 Agricultural Practices

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

2.6.2 Increased Urbanization

The Delta region, which include portions of Contra Costa, Solano, San Joaquin, and Sacramento counties, is one of the fastest growing regions in California. The population is growing by approximately one percent per year, adding 348,000 people in 2015 (CDOF 2016). Many of these people are settling in the Central Valley. Some of the fastest growing cities are located near the Delta (e.g., Brentwood, Lathrop, and Elk Grove). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth has already placed additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those that are situated well away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation process with NMFS.

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

2.6.3 Global Climate Change

In section 2.4 (environmental baseline), 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 of time over which the Project is scheduled to be operated (four months a year for two years), 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.

2.7 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 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), 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) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Summary of the Status of the Species and Environmental Baseline

The Status of the Species, 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 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 their populations in the Central Valley. As a result, NMFS has determined in its most recent 5-year reviews (NMFS 2015, 2016a; and Williams 2016) that the listings are still warranted, and that the current status of these fish has continued to decline since the previous reviews in 2011.

Alterations in the geometry of the Delta channels (straightening), removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by diversions (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 action area.

The multi-year drought conditions in California from 2012 through 2016 have negatively affected winter-run, CV spring-run, and CCV steelhead, exacerbating the conditions that led to the species being listed. Lethal water temperatures below the rim dams have reduced the viability of eggs in the gravel for winter-run and CV spring-run, and have made tributaries excessively warm over the summer and fall seasons due to a lack of snow and snow melt runoff. Early life stages of sDPS 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.

2.7.2 Summary of Effects of the Proposed Action

The proposed action will occur from March through June in 2018 and 2019. The effects of electrofishing surveys, tethering, hook and line surveys, DIDSON surveys, and hydrophones/acoustic receivers will be temporary and all gear will be removed immediately upon completion of the field season.

The proposed action will result in negative effects to winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon. NMFS expects that individuals will be harmed and injured, including the potential for mortalities, as a result of shocking during electrofishing surveys. However, these effects are expected to be minor in scope in relation to the species' respective populations, affecting a limited number of fish per year for each species.

2.7.3 Sacramento River Winter-Run Chinook Salmon

Adult and juvenile winter-run are expected to be migrating through the waters of the action area during the proposed electrofishing surveys. This activity has the potential to harm, injure, or kill winter-run. Hook and line surveys are not expected to negatively affect juvenile or adult winter-run, since Reclamation will use barbless hooks, limit the hook and line surveys to 32 hours a year, and specific fishing gear used does not target salmonids or sturgeon. The operations of the mobile DIDSON cameras and acoustic hydrophones produce sound at frequencies above the hearing bandwidth of salmonids and green sturgeon. Thus, the operation of the DIDSON cameras and hydrophones is not expected to have any impact on salmonids or green sturgeon that move through the sound field projected by the equipment. The acoustic hydrophones are passive and only detect the pings of the acoustic tags placed in the hatchery fish and do not emit any sound themselves. Retrieval of the hydrophones 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.

Electrofishing will be conducted 1 day per month from March through June in 2018 and 2019. Reclamation will electrofish for 8 hours a day at the four sites for a total of 32 hours per year. Electrofishing will not occur within 1 hour of the release of salvaged fish at release sites. If hatchery juvenile Chinook salmon tagging occurs in 2019, they will be tagged and released with the salvaged fish that are trucked from the TFCF. Since electrofishing will not be conducted within 1 hour of the fish releases, ESA-listed fish that are salvaged at the Fish Facilities are not likely to be in the immediate near-shore area, or exposed to the activity that is intended to collect targeted predators.

NMFS estimates that very few juvenile winter-run will be encountered during electrofishing due to the timing of the Project, because the number of winter-run is likely very low, and smaller fish are less affected by electrofishing currents used to target larger fish. According to normalized Delta Juvenile Fish Monitoring Program (DJFMP) data, 46 percent of juvenile winter-run migrate through the Delta from March through June (USFWS 2016). From 2000 to 2016, an average of 68 winter-run (length-at-date) were collected at monitoring locations in March, 41 in April, 2 in May, and 1 in June (total of 112 fish).

Total electrofishing time will be no more than 8 hours per day. Actual shocking time will be less: approximately 17 to 133 minutes per event. Based on a conservative maximum total electrofishing time of 32 hours, electrofishing will occur 1.10 percent of the 4-month period (32 hours/2,920 hours possible in the 4-month period). If we assume that all 112 winter-run collected at monitoring locations throughout the Delta will be present in the action area, and electrofishing occurs 1.10 percent of the time, then approximately 1.2 fish (0.0110 x 112 fish) will be present in the action area during the 32 hours of electrofishing. Approximately 2 juvenile winter-run would be exposed to the electric current from electrofishing. This represents 0.000061 percent (1.2/201,409*100%) of the juvenile production estimated to enter the Delta in water year 2018 (NMFS 2018). It is even more unlikely that juvenile winter-run will be within range of the electrofisher on Horseshoe Bend or Curtis Landing since they tend to stay in the main channel of the Sacramento River or rear in the north Delta (Cache Slough Complex) outside of the action area.

Vulnerability of adult winter-run during electrofishing will be dependent on fish movements in the area of electrofisher boat location. Most adult winter-run migrate through the Delta in a matter of days from December through May, staying within the Sacramento River main channel. However, they could potentially travel close enough to the release sites and be affected by the electric current. Juveniles and adults tend to be crepuscular (i.e., active at dawn and dusk), and they migrate mainly at night (Chapman et al. 2012, CDFW 2016). Since electrofishing will only occur during the day, there is less chance of exposure.

Juvenile and adult ESA-listed fish are not likely to encounter the electric current from the electrofishing boat, since they are more likely to be present in the main channel rather than near the shoreline (in the action area). Any ESA-listed fish that do encounter the electric current may be temporarily immobilized, and possibly netted, before being identified and returned to the water. Any dead ESA-listed fish would be delivered to the TFCF for analysis, however, no ESA-listed fish were collected during the 2017 trammel net sampling, and no ESA-listed fish were collected during the referenced Miranda et al. (2010) study. The only Chinook salmon and steelhead recorded during the Miranda et al. (2010) study were hatchery fish and no mortalities resulted from electrofishing. Smaller fish, such as juvenile salmonids, would be less affected by the electric current than larger fish. The potential for injury or mortality increases with the volume of the fish. Immobilized fish are also more susceptible to predation in the presence of larger predators such as striped bass, largemouth bass, and pikeminnows, however, other fish close by would also likely be immobilized and unable to take advantage of their impaired state.

In summary, the harassment of a small number of winter-run by temporary immobilization as a result of electrofishing is not expected to impact the population's likelihood of survival and recovery.

2.7.4 Central Valley Spring-Run Chinook Salmon

The risk to CV spring-run in relation to the effects from electrofishing is higher than to winter-run since the Project overlaps more of their emigration timing and the population of CV spring-run is larger than the population of winter-run. Both adult and juvenile CV spring-run may be present in the action area during all Project activities. Similar to winter-run, the placement, operation, or retrieval of the DIDSON camera and acoustic equipment are not expected to result in any negative response to juvenile or adult CV spring-run because the sound frequencies used are above the hearing range of salmonids. Hook and line surveys are not expected to negatively affect juvenile or adult CV spring-run since, similar to winter-run, Reclamation will be using specific fishing gear that does not target salmonids or sturgeon.

Based on normalized DJFMP data (USFWS 2016), approximately 87 percent of the juvenile CV spring-run population is expected to pass through the Delta from March through June. Adult CV spring-run are expected to be migrating upstream through the Delta during the same time. Therefore, there is a risk that electrofishing may affect both adult and juvenile CV spring-run. As mentioned for winter-run, adult and juvenile CV spring-run tend to stay in the main channel of the Sacramento River and are less likely to be present near the release site locations.

From 2000 to 2016, an average of 210 juvenile CV spring-run (length-at-date) were collected at monitoring locations in March, 1,534 in April, 472 in May, and 15 in June (total of 2,230 fish). As discussed above for winter-run, electrofishing will occur 1.10 percent of the 4-month period (32 hours/2,920 hours possible in 4 months). Since there is not an equivalent juvenile production estimate for spring-run, we do not have a current total population estimate. If an average of 2,230 CV spring-run are collected at monitoring locations throughout the Delta during March through June, and electrofishing occurs 1.10 percent of the time, if we assume that all 2,230 fish will be present in the action area, then approximately 25 juvenile CV spring-run (0.0110 x 2,230 fish) may be exposed to the effects of electrofishing. This estimate is conservative since juvenile CV spring-run are more likely to be in the main channel of the Sacramento River or rear in the north Delta (Cache Slough Complex) outside of the action area, rather than along the shallow shoreline within range of the electrofisher on Horseshoe Bend (off the Sacramento River) or Curtis Landing (on the San Joaquin River).

Adult CV spring-run are expected to be migrating upstream through the action area primarily in February to April, which overlaps with the March through June Project activities. Use of sampling methods during the daytime will expose fewer CV spring-run adults and juveniles based on the expected diurnal/nocturnal movement behavior mentioned above under winter-run.

In summary, a small number of CV spring-run may be harassed, harmed, or killed as a result of electrofishing. These effects are expected to impact only a limited number of individual fish per year in 2018 and 2019. The loss of a few individuals is not expected to rise to the level where it would reduce appreciably the population's likelihood of survival and recovery.

2.7.5 California Central Valley Steelhead

Both adult and juvenile CCV steelhead will be present in the Delta during electrofishing surveys, hook and line surveys, tethering, and hydrophone use throughout the Project. For the same reasons previously explained for winter-run and CV spring-run, operation of the electrofisher is likely to result in negative effects to CCV steelhead within the action area. Hook and line surveys are not expected to negatively affect juvenile or adult CCV steelhead since, similar to winter-run and CV spring-run, Reclamation will be using specific fishing gear that does not target salmonids or sturgeon. Also, as described above, the deployment, retrieval and operation of the DIDSON camera and hydrophones are not expected to negatively affect either adult or juvenile CCV steelhead in the action area.

Approximately 70 percent of the adult CCV steelhead population in the Sacramento River basin moves upriver to spawn from September to November (McEwan 2001). However, unlike salmon, not all steelhead die after spawning. A small percentage (typically females) return to the ocean in the spring (Null *et al.* 2013). These adult steelhead that have spawned (kelts) and migrate downstream are in poor condition and less likely to avoid the electric field of the electrofisher (Teo *et al.* 2011). Although the average size of CCV steelhead is typically smaller than adult Chinook salmon, CCV steelhead adults are expected to experience similar negative effects from electrofishing, including muscle contractions causing temporary immobilization, or possible spinal injury leading to mortality.

Based on normalized DJFMP data (USFWS 2016), approximately 76% percent of the annual juvenile CCV steelhead population is expected to pass through the Delta from March through June. Movement of these juvenile CCV steelhead through the Delta may be associated with increases of tributary flows, and are more variable than for Chinook salmon. Based on the location of the sampling activities away from the main migratory pathway (main channels) only a small number of juvenile CCV steelhead are likely to be affected by electrofishing.

From 2000 to 2016, an average of 31 steelhead (5 in March, 11 in April, 13 in May, and 2 in June) were collected at DJFMP monitoring locations in March through June. As discussed above for winter-run and CV spring-run, electrofishing will occur 1.10 percent of the 4-month period (32 hours/2,920 hours possible in 4-months). If we assume that all 31 CCV steelhead are present in the action area, and if electrofishing occurs 1.10 percent of the time, then the approximate number of juvenile CCV steelhead that may be exposed to the effects of electrofishing is 0.3 fish (0.0110 x 31 fish). This estimate is conservative since juvenile CCV steelhead are more likely to be in the main channels than along the shoreline where sampling activities will occur.

In summary, a small number of adult and juvenile CCV steelhead may be harassed, harmed, or killed as a result of electrofishing. These effects are expected to impact only a limited number of juveniles (<1) per year based on DJFMP data from 2000 to 2016. The loss of these individuals is not expected to rise to the level where it would appreciably reduce the population's likelihood of survival and recovery.

2.7.6 Southern DPS Green Sturgeon

Since juvenile sDPS 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 electrofishing surveys, hook and line surveys, tethering lines, and DIDSON camera and hydrophones during their deployment, operation, and retrieval (**Table 6**). Currently, there is not a reliable measure of juvenile sDPS 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 sDPS green sturgeon presence is assumed to occur year-round without knowing the monthly proportion of the population.

Adult sDPS green sturgeon are migrating upstream through the Delta to the Sacramento River from March to July (Moyle 2002) and outmigrating downstream from November to December and from June to August (Heublein and J.T. Kelly 2009). Hence, there may be adult sDPS green sturgeon migrating upstream or downstream during Project activities.

As discussed above for Chinook salmon, the operation of the DIDSON camera and hydrophones are not expected to negatively affect either adult or juvenile green sturgeon in the action area. Any noise produced during the deployment of the hydrophones and DIDSON are not likely to produce sound exposures that would cause injury or death to exposed sDPS green sturgeon due to their short-term duration and magnitude. The operations of the DIDSON produces sound at frequencies above the hearing bandwidth of sDPS green sturgeons. Thus, the operation of the acoustic equipment is not expected to have any impact on sDPS green sturgeon that are moving within the range of the equipment. The acoustic hydrophones are passive and only detect the high-frequency sound of the acoustic tags placed in the study fish and do not emit any sound themselves. Retrieval of the hydrophones may cause some transient noise (130 to140 dB) 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 (i.e., above the 150 dB threshold for behavioral sound effects) to cause harm or behavioral modifications to any fish in the vicinity.

Hook and line surveys are unlikely to harm adult or juvenile sDPS green sturgeon since the fishing gear that will be used is completely different than what you would target sturgeon with, and hook and line surveys will occur in shallow waters surrounding the four sites, where sturgeon are unlikely to be present.

Both adult and juvenile green sturgeon may be exposed to electrofishing. According the CDFW fishing report cards in the Delta, an average of 66 sDPS green sturgeon were caught from March through June (CDFW 2008-2014). These fish were assumed to be caught by anglers using bait that targets white sturgeon, and in deeper waters where sturgeon are more likely to be present. If we assume that all 66 fish are present in the action area from March through June, and electrofishing occurs 1.10 percent of the time, then 0.7 adult sDPS green sturgeon (0.011 x 66 fish) may be affected by electrofishing. This estimate is conservative since adult green sturgeon are unlikely to be in shallow waters at the time electrofishing surveys will be occurring. However, any adult sDPS green sturgeon that are within the range of the electric field during electrofishing surveys would be severely injured and most likely killed, due to their large size (Dolan and Miranda 2003).

The DJFMP rarely catches juvenile green sturgeon at seine and trawl monitoring sites due to their tendency to remain at deeper depths. From 1976 to 2016, only 18 juvenile green sturgeon were reported (USFWS 2016). From 1981 to 2012, 7,200 juveniles were reported at the State and Federal export facilities, with a higher presence of juvenile green sturgeon during the spring and summer months in the south Delta where export facilities are located (CDFW 2016). The average salvage of juvenile green sturgeon was 23 in March, 81 in April, 44 in May, and 13 in June (total of 161). If we assume that all 161 juveniles are present in the action area, then 1.8 fish (0.0110 x 161 fish) may be exposed to the effects of electrofishing when surveys are occurring. Green sturgeon can be particularly vulnerable to electrofishing due to their physical size. If juvenile sDPS green sturgeon are encountered by the electric current, they would likely be immobilized or suffer more severe injuries, and may or may not be observed by crew.

In summary, less than 1 adult and 2 juvenile sDPS green sturgeon may be harmed or killed as a result of electrofishing. Recently, an annual run size has been estimated at 272 adults in the

Sacramento River, with a total population size of 1,008 (Mora 2014). The proposed action is expected to impact only a small number (3) of fish per year in 2018 and 2019. If the action were to result in the mortality of one adult and two juvenile green sturgeon, it would represent 0.298 percent (3/1,008*100%) of the estimated population. The loss of an adult or a couple of individual juveniles is not expected to rise to the level where it will appreciably reduce the population's likelihood of survival and recovery.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon.

2.9 Incidental Take Statement

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

The measures described below are non-discretionary and must be undertaken by 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]).

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

NMFS anticipates that the proposed action may result in the incidental take of individual adult and juvenile winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon. Incidental take associated with this action is expected to be in the form of harassment, injury, or mortality. The operations of electrofishing during the Project field seasons from March through June in 2018 and 2019 is expected to result in direct impact of direct current immobilizing or injuring fish in the area.

The number of ESA-listed fish species observed during electrofishing surveys 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.

- During electrofishing surveys, fish that are found dead or alive but with obvious injuries of a serious nature (i.e., broken spine), will be considered as lethal take. Total take, which includes both non-lethal and lethal take, are provided in
- **Table 8**.

Table 8. Summary of incidental take exempted for the proposed action per season through exposure of electric current, netting, handling, and releasing fish during electrofishing surveys.

ESA-listed species	Lifestage	Lethal	Non-lethal	Total
Winter-run	Adult[1]	0	2	2
	Juvenile[2]	0	2	2
CV Spring-run	Adult[1]	1	4	5
	Juvenile[2]	2	25	27
CCV steelhead	Adult[1]	1	2	3
	Juvenile[2]	0	1	1
sDPS green sturgeon	Adult[3]	1	0	1
	Subadults	1	2	3

[1] An adult Chinook salmon or CCV steelhead will be considered as any fish greater than 400 mm FL
[2] Run determined by the length-at-date classification (Delta model)
[3] An adult sDPS green sturgeon, will be considered as any green sturgeon greater than 100 cm FL

2.9.2 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

2.9.3 Reasonable and Prudent Measures

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

1. Reclamation shall ensure all electrofisher operators have proper training and experience.

2. Electrofishing surveys shall start with all settings set to the minimums needed to capture fish and be gradually increased.

3. Reclamation shall record water temperature (°C), conductivity (µS/cm), and dissolved oxygen (% and mg/L) at each sampling event, and record the number and species of fish observed and the number of mortalities.

4. Measures shall be taken to minimize impacts to listed salmonids or sDPS green sturgeon that are captured during electrofishing.

5. Reclamation shall monitor and report incidental take to NMFS.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). NMFS 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 ITS (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 ensure all electrofisher operators have proper training and experience.

   a) Electrofishing boat operators must have appropriate training and experience with electrofishing techniques. Training for field supervisors can be acquired from programs such as those offered from the USFWS - National Conservation Training Center (Principles and Techniques of Electrofishing course) where participants are presented information concerning such topics as electric circuit and field theory, safety training, and fish injury awareness and minimization. A crew leader having at least 100 hours of electrofishing experience in the field using similar equipment must train the crew. The training must occur before an inexperienced crew begins any electrofishing and should be conducted in waters that do not contain ESA-listed fish. Field crew training should include the following basic elements:
      i. A review of these guidelines and the equipment manufacturer’s recommendations, including basic gear maintenance.
      ii. Definitions of basic terminology (e.g. galvanotaxis, narcosis, and tetany) and an explanation of how electrofishing attracts fish.
      iii. A demonstration of the proper use of electrofishing equipment (including an explanation of how gear can injure fish and how to recognize signs of injury) and of the role each crew member performs.
      iv. A demonstration of proper fish handling, anesthetization, and resuscitation techniques.
      v. A field session where new individuals actually perform each role on the electrofishing crew (NMFS 2000).

2. Electrofishing surveys shall start with all settings set to the minimums needed to capture fish and be gradually increased.

a) Electrofishing equipment must be in good working condition and operators should go through the manufacturer's preseason checks, adhere to all provisions, and record major maintenance work in a logbook. Each electrofishing session must start with all settings (voltage, pulse width, and pulse rate) set to the minimums needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured. Only direct current (DC) or pulsed direct current (PDC) should be used.

b) Recommended applied voltages for fishing in low conductivity waters should be 300 to 400 Volts. At medium and high conductivities, progressively lower voltages will be effective in fish capture because a lower voltage gradient will elicit a response from fish at a given point in the electric field in higher conductivity waters. The following recommended guidelines will assist with most efficient capture and prevent unnecessary harm or injury to ESA-listed fish.

The following are recommended voltages for specific conductivity ranges (EIFAC):
- 150 to 500 µS/cm, use 200-300 Volts
- 500 to 800 µS/cm, use 150-200 Volts
- 800 to 1000 µS/cm, use 120-180 Volts
- >1000µS/cm : 100-150 Volts

3. Reclamation shall record water temperature (°C), conductivity (µS/cm), and dissolved oxygen (% and mg/L) at each sampling session, and record the number and species of fish observed and the number of mortalities.

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

4. Measures shall be taken to minimize impacts to listed salmonids or sDPS green sturgeon that are captured during electrofishing.

a) If any listed salmonids or sDPS green sturgeon are captured during electrofishing, Reclamation shall immediately return the fish to the water in a manner that will not induce further harm (i.e., not to be susceptible to the electric current for a second time). This can be accomplished by temporarily stopping electrofishing, or returning the fish to the water behind the boat, if there is enough distance from the anodes that the fish would not be shocked again.

5. Reclamation shall monitor and report incidental take to NMFS.

    a) Any Chinook salmon, steelhead, or green sturgeon found dead or injured within 0.25 miles upstream or downstream of survey sites during the field season shall be reported immediately to NMFS via fax or phone within 24 hours of discovery to:

        Assistant Regional Administrator
        NMFS California Central Valley Office
        Fax at (916) 930-3629, or
        Phone at: (916) 930-3600

    b) Any dead specimen(s) shall be placed in a cooler with ice and sent to: NMFS, Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

    c) Reclamation shall make records/log books available to any personnel from NMFS's Office of Law Enforcement, or CDFW Wardens, upon request for review of compliance with the terms and conditions.

    d) Reclamation biologists shall carry a copy of the ITS at all times while in the field.

    e) By July 31 of each Project season, Reclamation shall provide a written report to NMFS containing a summary of:
        i. environmental conditions encountered during the gear deployment;
        ii. the numbers of any listed species captured by species or run during surveys; and
        iii. the number of listed species mortalities by species and run. **Annual Report(s):** Implementation of the monitoring and evaluation activities authorized under this biological opinion is contingent upon receipt of annual reports. Annual reports must be submitted online through the NMFS, Applications and Permits for Protected Species website; **https://apps.nmfs.noaa.gov,** by July 31 of each year. Once an annual report is submitted to NMFS, Reclamation may continue authorized activities unless otherwise notified by NMFS. Reclamation will be notified by NMFS if the annual report is inadequate and more information is required. If information is requested but not supplied, this biological opinion may be suspended until the NMFS request is met.

        National Marine Fisheries Service Applications and Permit Contact:
        Amanda Cranford
        National Marine Fisheries Service
        650 Capitol Mall, Room 5-100
        Sacramento, California 95814
        Phone: (916) 930-3706
        Fax: (916) 930-3629
        Email: Amanda.Cranford@noaa.gov

2.10 Conservation Recommendations

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

- Reclamation should fund studies to help quantify predation loss of ESA-listed species directly in front of the TFCF. This pre-screen loss rate has never been quantified and is currently based on an assumed value, which may underestimate the actual loss rate.

- Reclamation should continue to work cooperatively with NMFS, DWR, CDFW, and USFWS to identify opportunities to reduce predation in and around the Fish Salvage Facilities and further the implementation of the Central Valley Salmon Recovery Plan (NMFS 2014).

2.11 Reinitiation of Consultation

This concludes formal consultation for the 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Project (Reinitiation 2018).

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

2.12 "Not Likely to Adversely Affect" Determinations

The applicable standard to find that a Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur.

NMFS has determined that while the proposed action may affect critical habitats for winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon due to the placement of anchors and tethering line weights, the proposed action is not likely to adversely affect critical habitats for the above listed species.

2.13 Effects of the Project on Designated Critical Habitats

The Project will have insignificant effects on the designated critical habitats for winter-run, CV spring-run, CCV steelhead, and sDPS 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 are food resources, water flow, water quality, migratory corridors, water depth, and sediment quality.

The minimal contact with the underlying channel substrate from fishing gear is not expected to result in any negative changes to the substrate for winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon designated critical habitats that might impact production of forage organisms or disturb habitat complexity or composition. Since tether lines will only be deployed during the day for short periods of time (4.5 hours per day), and will not be anchored to the bottom, they will have no impacts to the PBFs for sDPS green sturgeon related to physical or biotic criteria except as a migratory corridor. The 20–40 anchors for the acoustic arrays are not likely to substantially alter or degrade the function or value of the substrate. The bottom substrate will return to an undisturbed condition within minutes of removal of the anchors. The temporary presence of the tether lines and acoustic telemetry arrays will impede <1% of channel width that they will be deployed in, and will not impede on the migratory corridor pbf of any of the designated critical habitats. Acoustic effects from work boats used to deploy monitoring gear are anticipated to be minimal, and are not expected to rise to the level where fish species could be impacted (i.e., above the background level for San Francisco Bay, or 150 dB). Therefore, the proposed Project is not likely to adversely affect critical habitat in the action area because the impacts are so small as to be insignificant.

3. 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.

3.1 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 Reclamation and NMFS. Other interested users could include USFWS and CDFW. Individual copies of this opinion were provided to Reclamation, USFWS, and CDFW. This opinion will be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

3.2 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.

3.3 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 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 reviewed in accordance with West Coast Region ESA quality control and assurance processes.

4. REFERENCES

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gringas, B. Herbold, A. Mueller-Solger, and T. Sommer. 2007. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Available at: http://www.fws.gov/sacramento/es/documents/POD_report_2007.pdf.

Beccio, M. 2017. Telemetric Monitoring results of sDPS green sturgeon in the lower Sacramento/San Joaquin Delta. Presentation to the Interagency Ecological Program 2017 Annual Workshop at Lake Natoma Inn, Folsom CA. March 1-3, 2017.

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Standford, P. Kiffney, and N. Mantua. 2012. Restoring Salmon Habitat for a changing climate. River Research and Applications. 22 pages.

Boswell, K. M., M. P. Wilson, and J. H. Cowan. 2008. A Semiautomated Approach to Estimating Fish Size, Abundance, and Behavior from Dual-Frequency Identification Sonar (DIDSON) Data. North American Journal of Fisheries Management 28(3):799-807.

Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook Salmon Abundance, Distribution, and Survival in the Sacramento-San Joaquin Estuary. Fish Bulletin 179(2):39-138.

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In L. R. Brown ed.), Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science 1(1).

Brown, L. R. and D. Michniuk. 2007. Littoral Fish Assemblages of the Alien-Dominated Sacramento–San Joaquin Delta, California, 1980–1983 and 2001–2003. Estuaries and Coasts 30:186–200.

Burwen, D. L., S. J. Fleischman, and J. D. Miller. 2011. Accuracy and Precision of Salmon Length Estimates Taken from DIDSON Sonar Images. Transactions of the American Fisheries Society 139(5):1306-1314.

California Department of Finance. 2016. Annual population and growth reports. http://www.dof.ca.gov/research/demographic/.

California Department of Fish and Game. 2016. GrandTab, unpublished data 1975-2016. California Central Valley Chinook Population Database Report. http://www.dfg.ca.gov/fish/Resources/Chinook/CValleyAssessment.asp.

California Department of Fish and Game. 1990. Status and Management of Spring-run Chinook Salmon. Inland Fisheries Division, 33 pp.

California Department of Fish and Game. 1998. A status review of the spring-run Chinook salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage. Report to the Fish and Game Commission. Candidate Species Status Report 98-01. Sacramento, California, 394 pages.

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

California Department of Fish and Game. 2011. Sturgeon Fishing Report Card: 2010 Preliminary Data Report. Bay Delta Region (East). 14 pp.

California Department of Fish and Game. 2012. GrandTab Spreadsheet of Adult Chinook Escapement in the Central Valley. http://www.calfish.org/tabid/104/Default.aspx.

California Department of Fish and Wildlife. 2014. Adult Sturgeon and Striped Bass Fish Report Cards 2008-2014. Stockton, CA.

California Department of Fish and Wildlife. 2013. Mossdale Kodiak Trawl, San Joaquin River, unpublished data. Region 1.

California Department of Fish and Wildlife. 2016. Fish salvage data from the Tracy and Skinner Fish Facilities. ftp://ftp.dfg.ca.gov/salvage/DOSS_Salvage_Tables/

California Department of Fish and Wildlife. 2017. Grandtab Spreadsheet of California Central Valley Chinook Population Database Report. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381

Castillo, G., J. Morinaka, R. Fujimura, J. DuBois, B. Baskerville-Bridges, J. Lindberg, G. Tigan, L. Ellison, and J. Hobbs. 2014. Evaluation of Calcein and Photonic Marking for Cultured Delta Smelt. North American Journal of Fisheries Management 34(1):30-38.

Catalano, M. J., S. R. Chipps, M. A. Bouchard, and D. Wahl. 2001. Evaluation of Injectable Fluorescent Tags for Marking Centrarchid Fishes: Retention Rate and Effects on Vulnerability to Predation. North American Journal of Fisheries Management 21(4): 911-917.

Cavallo, B., D. L. Brown, R. , J. Kindopp, and R. Kurth. 2011. Hatchery and Genetic Management Plan for Feather River Hatchery Spring-run Chinook Program. Prepared for the National Marine Fisheries Service.

Chapman, E. D., A. R. Hearn, C. J. Michel, A. J. Ammann, S. T. Lindley, M. J. Thomas, P. T. Sandstrom, G. P. Singer, M. L. Peterson, R. B. MacFarlane, and A. P. Klimley. 2012. Diel movements of out-migrating Chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss) smolts in the Sacramento/San Joaquin watershed. Environmental Biology of Fishes 96(2-3):273-286.

Chase, R. 2010. Lower American River steelhead (Oncorhynchus mykiss) spawning surveys – 2010. Department of the Interior, US Bureau of Reclamation.

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

Cramer Fish Sciences. 2011. Hatchery and Genetic Management Plan for Feather River Hatchery Spring-run Chinook Salmon. Prepared for the California Department of Water Resources, 69 pp.

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

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

Dimacali, R. L. 2013. A modeling study of changes in the Sacramento River winter-run Chinook salmon population due to climate change. Master's Thesis in Civil Engineering presented to California State University, Sacramento, CA. 64 pages.

Dolan, C. R. and L. E. Miranda. 2003. Immobilization Thresholds of Electrofishing Relative to Fish Size. Transactions of the American Fisheries Society 132(5):969-976.

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

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries Volume II: Species Life History Summaries.

European Inland Fisheries Advisory Commission. WORKING PARTY ON FISH MONITORING IN FRESH WATERS. Electric Fishing Best Practice.10.

FishBio. 2010. Electrofishing. Fish Monitoring. https://fishbio.com/field-notes/fish-monitoring/electrofishing.

FishBio. 2012. San Joaquin Basin Update. San Joaquin Basin Newsletter, Oakdale, California.

Florida Fish and Wildlife Conservation Commission. Electrofishing FAQ. http://myfwc.com/research/freshwater/resources/techniques/electrofishing-faq/.

Franks, S. E. 2015. Spring-running Salmon in the Stanislaus and Tuolumne Rivers and an Overview of Spring-run Recovery. National Marine Fisheries Service Sacramento, CA.

Garza, J. C. and D. E. Pearse. 2008. Population genetic structure of Oncorhynchus mykiss in the California Central Valley: Final report for California Department of Fish and Game. University of California, Santa Cruz, and National Marine Fisheries Service, Santa Cruz, California.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66, 637 pp.

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

Hallock, R. J. and F. W. Fisher. 1985. Status of Winter-Run Chinook Salmon, Oncorhynchus Tshawytscha, in the Sacramento River.28.

Hallock, R. J., W. F. Van Woert, and L. Shapolalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (Salmo gairdnerii gairdnerii) in the Sacramento River system. State of California Department of Fish and Game Fish. Bulletin No.114.

Hannon, J. and B. Deason. 2008. American River Steelhead (*Oncorhynchus mykiss*) Spawning 2001 – 2007. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region.

Hannon, J., M. Healey, and B. Deason. 2003. American River Steelhead (Oncorhynchus mykiss) Spawning 2001 – 2003. U.S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, CA.

Hayes, M. C., S. M. Focher, and C. R. Contor. 2000. High-Pressure Injection of Photonic Paint to Mark Adult Chinook Salmon. North American Journal of Aquaculture 62(4):319-322.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101(34)12422-12427.

Heublein, J. C. and C. E. C. J.T. Kelly, A.P. Klimley, and S.T. Lindley. 2009. Migration of green sturgeon, Acipenser medirostris, in the Sacramento River. Environmental Biology of Fish 84:245-258.

Holmes, J., G. Cronkite, H. Enzenhofer, and T. Mulligan. 2006. Accuracy and precision of fish-count data from a “dual-frequency identification sonar” (DIDSON) imaging system. ICES Journal of Marine Science 63(3):543-555.

Huang, B. and Z. Liu. 2000. Temperature Trend of the Last 40 Years in the Upper Pacific Ocean. Journal of Climate 4:3738-3750.

Intergovernmental Panel on Climate Change. 2001. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, New York. 881 pages.

Israel, J. and B. May. 2010. Indirect genetic estimates of breeding population size in the polyploid green sturgeon (Acipenser medirostris). Molecular Ecology 19(5):1058-70.

Israel, J. A., K. J. Bando, E. C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (Acipenser medirostris). Canadian Journal of Fisheries and Aquatic Sciences 66(9):1491-1504.

Jackson, Z.J and J. P. Van Eenennaam. 2013. 201 San Joaquin River Sturgeon Spawning Survey. Final Annual Report. USFWS, Stockton Fish and Wildlife Office, Lodi, CA.

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

Lindley, S. T., R. S. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2006. Historical Population Structure of Central Valley Steelhead and its Alteration by Dams. San Francisco Estuary and Watershed Science 4(1):19.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. L. Rechisky, J. T. Kelly, J. Heublein, and A. P. Klimley. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137(1):182-194.

Lindley, S. T., M. S. M. C. B. Grimes, W. Peterson, J. Stein, J. T. Anderson,, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza,, D. G. H. A. M. Grover, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane,, M. P.-Z. K. Moore, F. B. Schwing, J. Smith, C. Tracy, R. Webb,, and T. H. W. B. K. Wells. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication to the Pacific Fishery Management Council. 118 pages. March 18.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries. Transactions of the American Fisheries Society 140(1):108-122.

MacFarlane, B. R. and E. C. Norton. 2002. Physiological ecology of juvenile Chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin. 100:244-257.

Matala, A. P., S. R. Narum, W. Young, and J. L. Vogel. 2012. Influences of Hatchery Supplementation, Spawner Distribution, and Habitat on Genetic Structure of Chinook Salmon in the South Fork Salmon River, Idaho. North American Journal of Fisheries Management 32(2):346-359.

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

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

McEwan, D. and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, 246 pp.

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

Miranda, J., R. Padilla, J. Morinaka, J. DuBios, and M. Horn. 2010. Release Site Predation Study.

Mohler, J. W., M. J. Millard, and J. W. Fletcher. 2002. Predation by Captive Wild Brook Trout on Calcein-Marked versus Nonmarked Atlantic Salmon Fry. North American Journal of Fisheries Management 22(1): 223-228.

Mora, E. A. 2014. Abundance and Distribution of Green Sturgeon during their Spawning Period. Unpublished data from Sacramento River tagging studies in 2010, 2011, and 2012. Graduate Group in Ecology, University of California, Davis, California.

Moser, M. L. and S. T. Lindley. 2006. Use of Washington Estuaries by Subadult and Adult Green Sturgeon. Environmental Biology of Fishes 79(3-4):243-253.

Mosser, C. M., L. C. Thompson, and J. S. Strange. 2012. Survival of captured and relocated adult spring-run Chinook salmon Oncorhynchus tshawytscha in a Sacramento River tributary after cessation of migration. Environmental Biology of Fishes(DOI 10.1007/s10641-012-0046).

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

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

Mueller, R. P., R. S. Brown, H. Hop, and L. Moulton. 2006. Video and acoustic camera techniques for studying fish under ice: a review and comparison. Reviews in Fish Biology and Fisheries 16(2):213-226.

National Marine Fisheries Service. 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.5.

National Marine Fisheries Service. 2009. Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. Protected Resources Division, Southwest Region, Long Beach, CA. 844 pages, plus 5 appendices.

National Marine Fisheries Service. 2010a. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species. U.S. Department of Commerce, 129-130 pp.

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

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

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

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

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

National Marine Fisheries Service. 2015. 5-Year Summary and Evaluation: Southern Distinct Population Segment of the North American Green Sturgeon U.S. Department of Commerce, 42 pp.

National Marine Fisheries Service. 2016a. 5-Year Review: Summary and Evaluation of the California Central Valley Steelhead Distinct Population Segment. U.S. Department of Commerce, 43 pp.

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

National Marine Fisheries Service. 2016c. Comprehensive Analyses of Water Export, Flow, Tide Height, and the Salvage and Abundance of Juvenile Salmonids in the Sacramento-San Joaquin Delta. NMFS Unpublished Data. 176 pages.

National Marine Fisheries Service. 2018. Winter-Run Chinook Salmon Juvenile Production Estimate for Brood Year 2017. http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Delta%20Operations%20for%20Salmonids%20and%20Sturgeon/DOSS%20WY%202018/winter-run_juvenile_production_estimate__jpe__for_brood_year_2017_-_january_29__2018__1_.pdf.

Nielsen, J. L., S. Pavey, T. Wiacek, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. U.S.G.S. Alaska Science Center - Final Technical Report submitted December 8, 2003. California Department of Fish and Game, Sacramento, California and U.S. Fish and Wildlife Service, Red Bluff, California.

Noakes, D. J. 1998. On the coherence of salmon abundance trends and environmental trends. North Pacific Anadromous Fishery Commission Bulletin 454-463.

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

Nobriga, M. L. and F. Feyrer. 2007. Shallow-Water Piscivore-Prey Dynamics in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5(2):2-13.

Nobriga, M. L., F. Freyrer, R. D. Baxter, and M. Chotkowski. 2005. Fish Community Ecology in an Altered River Delta: Spatial Patterns in Species Composition, Life History Strategies, and Biomass. Estuaries 28:776-785.

Null, R. E., K. S. Niemela, and S. F. Hamelberg. 2013. Post-Spawn Migrations of Hatchery-Origin Oncorhynchus mykiss Kelts in the Central Valley of California. Environmental Biology of Fishes (96):341–353.

Pacific States Marine Fisheries Commission (PSMFC). 2014. Juvenile Salmonid Emigration Monitoring in the Lower American River, California January – June 2013. Page 54. Prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, CA.

Peterson, J. H. and J. F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: Bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences 58:1831-1841.

Popper, A. N. 2005. A Review of Hearing by Sturgeon and Lamprey. Report submitted to the U.S. Army Corps of Engineers, Portland District on August 12, 2005. 24 pages.

Popper, A. N. and M. C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75(3), 455-489.

Poytress, W. R. and F. D. Carrillo. 2011. Brood-year 2008 and 2009 winter Chinook juvenile production indices with comparisons to juvenile production estimates derived from adult escapement., 51 pp.

Price, V. E., P. J. Auster, and L. Kracker. 2013. Use of High-Resolution DIDSON Sonar to Quantify Attributes of Predation at Ecologically Relevant Space and Time Scales. Marine Technology Society Journal 47(1):33-46.

Radtke, L. D. 1966. Distribution of Smelt, Juvenile Sturgeon, and Starry Flounder in the Sacramento-San Joaquin Delta with Observations on Food of Sturgeon. Fish Bulletin - Ecological Studies of the Sacramento-San Joaquin Delta. Part II: Fishes of the Delta(136).

Reynolds, F., T. Mills, R. Benthin, and A. Low. 1993. Restoring Central Vally Streams: A Plan for Action. California Department of Fish and Game, 217 pp.

Richter, A. and S. A. Kolmes. 2005. Maximum temperature limits for chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. Fisheries Science 13(1): 23-49.

Rutter, C. 1904. The Fishes of the Sacramento-San Joaquin Basin, With a Study of Their Distribution and Variation. Pages 103-152 *in* Bill of U.S. Bureau of Fisheries.

Seesholtz, A. M., M. J. Manuel, and J. P. Van Eenennaam. 2014. First documented spawning and associated habitat conditions for green sturgeon in the Feather River, California. Environmental Biology of Fishes 98(3):905-912.

Stachowicz, J. J., J. R. Terwin, R. B. Whitlatch, and R. W. Osman. 2002. Linking climate change and biological invasions: Ocean warming facilitates non-indigenous species invasions. PNAS, November 26, 2002. 99:15497-15500.

State Water Resources Control Board. 2014. CVP and SWP Drought Contingency Plan for October 15, 2014 through January 15, 2015. Prepared by the Reclamation and CDWR, working with the USFWS, NMFS and CDFW. October 15, 2014, 11 pages.

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

Teo, S. L. H., P. T. Sandstrom, E. D. Chapman, R. E. Null, K. Brown, A. P. Klimley, and B. A. Block. 2011. Archival and acoustic tags reveal the post-spawning migrations, diving behavior, and thermal habitat of hatchery-origin Sacramento River steelhead kelts (*Oncorhynchus mykiss*). Environmental Biology of Fishes(96):175-187.

Thompson, L. C., M. I. Escobar, C. M. Mosser, D. R. Purkey, D. Yates, and P. B. Moyle. 2011. Water management adaptations to prevent loss of spring-run Chinook salmon in California under climate change. Journal Water Resources Planning and Management. 10.1061/(ASCE)WR.1943-5452.0000194.

U.S. Army Corps of Engineers (Corps). 2013. Biological Assessment for the U.S. Army Corps of Engineers Authorized Operation and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River.

U.S. Bureau of Reclamation. 2008. High Pressure Injection of a Photonic Marking Agent: Mark Retention and Effects on Survival of Juvenile Striped Bass, Morone saxatilis, and Adult Delta Smelt, Hypomesus transpacificus. USDOI, Mid-Pacific Region, Tracy Fish Collection Facility Technical Series Vol. 34. 29 pages.

U.S. Bureau of Reclamation. 2014. West-Wide Climate Risk Assessment: Sacramento and San Joaquin Basins Climate Impact Assessment. U.S. Department of the Interior. Prepared by CH2M Hill for Reclamation. Contract No: R12PD80946. 66 pages.

U.S. Bureau of Reclamation. 2016. Biological Assessment for the 2017 Sacramento-San Joaquin River Delta Release Site Predation Project. U.S. Department of the Interior. Denver, Colorado. Issued October 20, 2016, 73 pages.

U.S. Fish and Wildlife Service. 2016. Delta Juvenile Fish Monitoring Program. 2000-2016 data. Fish and Wildlife Office, Lodi, California
https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm.

U.S. Fish and Wildlife Service. 2012. Abundance and Distribution of Chinook Salmon and Other Catch in the Sacramento-San Joaquin Estuary 2009. Annual Report Stockton Fish and Wildlife Office, USFWS, Stockton, CA. February. 74 pages.

U.S. Fish and Wildlife Service. 2015a. Clear Creek Habitat Synthesis Report USFWS Anadromous Fish Restoration Program, Sacramento, CA

U.S. Fish and Wildlife Service. 2015b. Juvenile Fish Monitoring Annual Report 2012-2013. Delta Juvenile Fish Monitoring Program. Lodi, CA. 133 pages.

U.S. Fish and Wildlife Service. 2016. Delta Juvenile Fish Monitoring Program. Annual report. USFWS, Fish and Wildlife Office, Lodi, California.

Van Rheenen, N. T., A. W. Wood, R. N. Palmer, and D. P. Lettenmaier. 2004. Potential implications of PCM climate change scenarios for Sacramento-San Joaquin river basin hydrology and water resources. Climate Change 62:257-281.

Vogel, D. and K. Marine. 1991. U.S. Bureau of Reclamation Central Valley Project Guide to Upper Sacramento River Chinook Salmon Life History. RDD/R42/003.51.

Whipple, A. A., R. M. Grossinger, D. Rankin, B. Stanford, and R. A. Askevold. 2012. Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process. Prepared for the CDFG and Ecosystem Restoration Program. A Report of SFEI-ASC's Historical Ecology Program, Publication #672, San Francisco Estuary Institute-Aquatic Science Center, Richmond, California.

Williams, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. February 2, 2016, Report to NMFS – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Yates, D., H. Galbraith, D. Purkey, A. Huber-Lee, J. Sieber, J. West, S. Herrod-Julius, and B. Joyce. 2008. Climate warming, water storage, and Chinook salmon in California's Sacramento Valley. Climate Change 91:335-350.

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

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

Federal Register Notices Cited

54 FR 32085. August 4, 1989. Emergency Interim Rule: Endangered and Threatened Species; Critical Habitat; Winter-Run Chinook Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 54, pages 32085-32088.

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

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

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

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

71 FR 834. January 5, 2006. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71, pages 834-862.

71 FR 17757. April 6, 2006. Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71, pages 17757-17766.

81 FR 7414. February 11, 2016. Final Rule: Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat. United States Department of the Interior and Commerce, U.S. Fish and Wildlife Service and National Marine Fisheries Service. *Federal Register*, Volume 81:28, pages 7414-7440.