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

APR 05 2017

Refer to NMFS No: WCR-2016-5840

Dr. Michael Horn
Manager Fisheries and Wildlife Group
U.S. Bureau of Reclamation
Technical Services 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 Study*

Dear Dr. Horn:

Thank you for your letter of November 16, 2016, requesting initiation of 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 Study* (Project).

You also requested consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)) for this Project. However, after reviewing the proposed action, we have concluded that the Project would not adversely affect EFH for Pacific Coast Salmon, Coastal Pelagics, or Pacific Groundfish, therefore, no EFH consultation is required.

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 gear. Therefore, an incidental take statement with non-discretionary terms and conditions is included.

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

Please contact Bruce Oppenheim at the California Central Valley Office at 916-930-3603, or via e-mail at bruce.oppenheim@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

for Barry A. Thom
Regional Administrator

Enclosure

cc: California Central Valley Office
Division Chron File: 151422-WCR2016-SA00285

Kaylee Allen, U.S. Fish and Wildlife Service, Bay-Delta Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814-4700

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

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

U.S. Bureau of Reclamation

NMFS Consultation Number: WCR-2016-5840

Action Agency: U.S. Bureau of Reclamation

Affected Species and NMFS's Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To 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

N/A = not applicable

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

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

Date: APR 05 2017

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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)
CDWR	California Department of Water Resources
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
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 of critical habitat
ppt	parts per thousand
Reclamation	U.S. Bureau of Reclamation
RPA	reasonable and prudent alternative
sDPS	southern distinct population segment
SWP	State Water Project
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USFWS	U.S. 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 study is being proposed to meet one or more of the required actions in 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 the Reasonable and Prudent Alternative (RPA) actions required in the NMFS 2009 Opinion, the U.S. Bureau of Reclamation (Reclamation) is requesting ESA section 7 formal consultation for *The 2017-2019 Sacramento-San Joaquin River Delta Release Site Predation Study* (Project). The proposed study is a necessary first step in meeting the NMFS (2009) RPA Action IV.4.3(3), which states:

> "*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 study is to meet RPA Action IV.4.3(4), which states:

> *"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 study would attempt 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 release site study comprised of representatives from California Department of Fish and Wildlife, (CDFW), U.S. Fish and Wildlife Service (USFWS), California Department of Water Resources (CDWR), and later on, NMFS. This team formulated the study goals, specific details of the study, and advised on permitting requirements.

The goal of the proposed 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 proposed 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 biological assessment (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 study through year 2019 and add additional research equipment. Because of this new information, February 13, 2017, was the date that the formal consultation was initiated.

- 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 (CCC steelhead not present and no designated critical habitat in the action area);
    - Not likely to adversely affect for the 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.

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 is proposing a one-year pilot study in 2017 to estimate predator abundance at multiple CVP/SWP fish release sites in the Delta using Dual Frequency Identification Sonar (DIDSON) camera technology and trammel nets. If the 2017 pilot study is successful (by meeting the 2 study goals, below), a follow up study is proposed for the spring of 2018 and 2019. The DIDSON observations will be paired with diet data from predators at the release pipes captured in trammel nets within 8-hour periods following release events. In addition, species-specific predator abundance from the trammel nets will be paired with total abundance as estimated using the DIDSON data to estimate species-specific abundance of large predators (*i.e.*, larger than 2.5 inches body depth) in close proximity to the release sites. Hatchery-raised juvenile Chinook salmon will be photonically marked and released through the release site pipe (200 per release) to detect diet samples of captured predators. These results will then be extrapolated to total abundance of predators to estimate predator loss.

The goals of the proposed Project are:

1. Estimate total abundance of large fish, assumed to be predators, and species-specific abundance of predators, before, during, and after a single fish release event during the juvenile Chinook salmon migration season (April through May, 2017; and March through May in 2018 and 2019) at multiple fish release sites.

2. Estimate total and species-specific predation loss of released fish at multiple release sites during the juvenile Chinook salmon migration season (April through May, 2017; and March through May in 2018 and 2019).

A. Project Activities

The DIDSON camera surveys will be utilized to estimate near-field abundance of large targets (*i.e.*, large predators) before, during, and after a single fish release event at two CVP release sites (Emmaton and Antioch) in 2017. SWP release sites may be used in 2018 and 2019. Stationary and mobile DIDSON camera surveys will be employed to examine predators inhabiting the waters near the release pipe outlets (Figure 1). One hour after each fish release event, multiple trammel nets (*i.e.*, 3 to 4) will be deployed in the water close to the release site (within the near-field area sampled by the DIDSON camera) and fished for an 8-hour period to catch large predators.

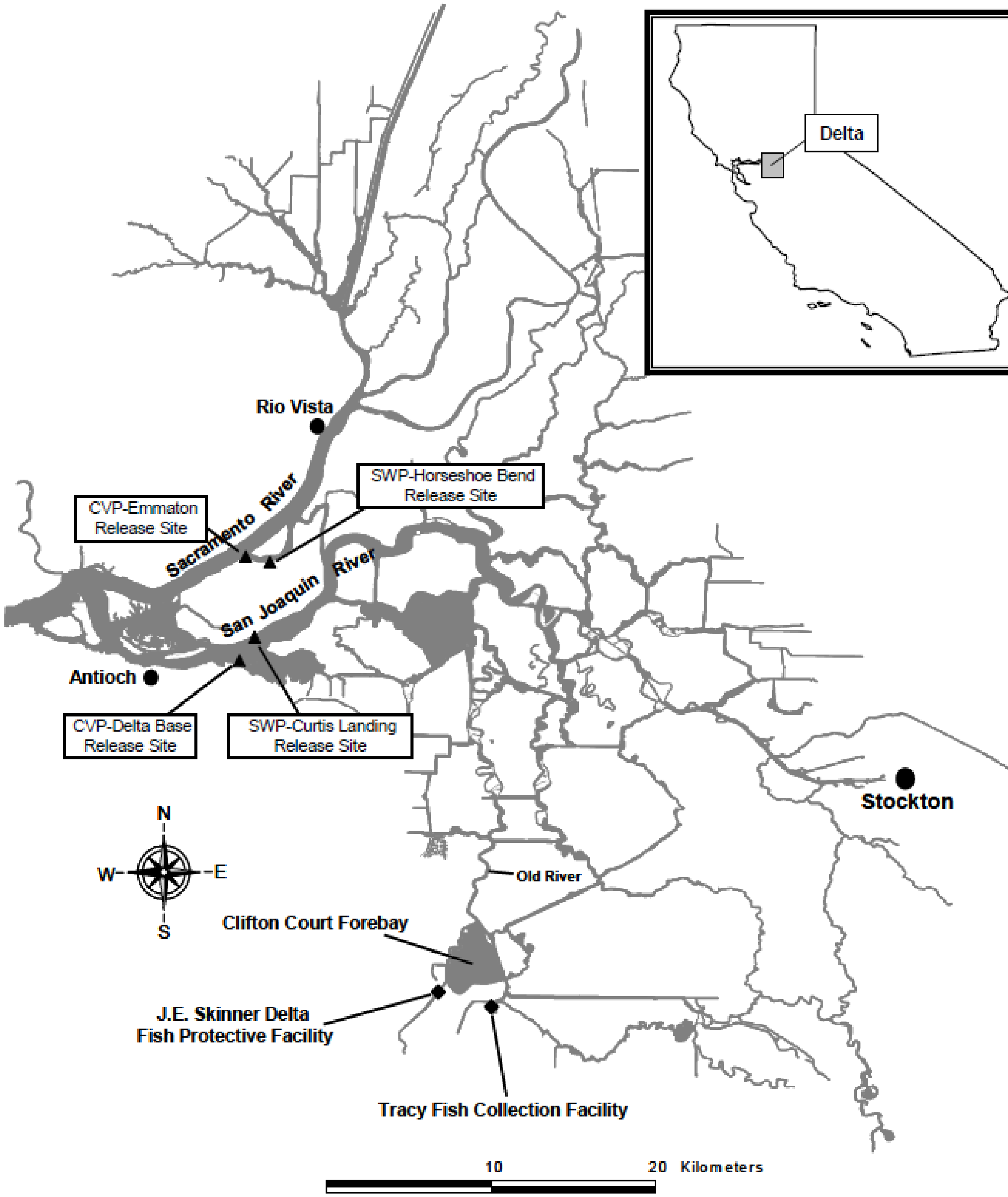

Figure 1. Location of the Fish Salvage Facilities and release site locations: Antioch (CVP-Delta Base) and CVP-Emmaton, SWP-Curtis Landing and SWP-Horseshoe Bend, in the Sacramento-San Joaquin Delta, California.

Trammel nets allow fish of selective sizes to be captured because of the small mesh of the internal wall and the larger mesh of the external walls. The nets will be able to capture most large-bodies predatory fishes while allowing small fish (*e.g.*, juvenile Chinook salmon and Delta Smelt (*Hypomesus transpacificus*) to escape. When non-target fish are captured in the trammel nets, they will recover in the water in floating net pens so they can regain and maintain equilibrium with normal gill ventilation and swimming activity. Once they have been revived and they display normal behavior (assessed visually by on-site biologists), they will be released back into the river under their own volition.

For each release event, 4 trammel nets will be deployed for 8 hours each. The trammel nets are 100 feet long and either 6 feet or 12 feet in depth. Trammel nets work well in turbid water such as the release sites. Each net consists of three parallel vertical layers of netting, decreasing in size, allowing the fish to swim through the first layer and get caught in pockets in the second and third layer from which they can be removed. Each net is equipped with floats attached to the head (top) rope and lead weights attached to the ground (bottom) rope. The nets will be anchored to the bottom using common cinder blocks (2 per net). Each cinder block anchor is 16 inches x 8 inches x 8 inches in size. The nets will be fished targeting slack tides (5-6 hours) to avoid drifting or pulling. All personnel will be Reclamation fisheries biologists.

Captured predators will be identified to species, measured, and weighed to provide an estimate of species-specific abundance. Diets will be collected from predators via non-lethal gastric lavage. Based on the data from previous studies (Miranda *et al*. 2009, Miranda and Padilla 2010), likely predators include: largemouth bass (*Micropterus salmoides*), striped bass (*Morone saxatilis*), and Sacramento pikeminnow (*Ptychocheilus grandis*). All ESA-listed species, included non-listed Chinook salmon, will be retrieved from the trammel nets, held for resuscitation in net pens (see description below), and returned to the water unharmed. Captured fish showing signs of stress will be resuscitated. No diets or other data will be collected from juvenile Chinook salmon or any ESA-listed species, as the priority will be to return them to water immediately. Data from such species are not important, as we do not anticipate juvenile Chinook salmon contributing to predation at the release sites.

In addition to recording morphometric characteristics of predatory caught via trammel net, gastric lavage will be performed on fish surviving capture, whereas stomachs will be surgically removed from mortalities. Gastric lavage will follow the methods of Kapuscinski *et al.* (2012). A small sample (n = 5) of each species of non-listed fish predators will be sacrificed after gastric lavage for quality assurance/quality control to verify lavage efficiency. Efforts will be made to sacrifice fishes that display poor resuscitation or are in poor condition after handling. All predators which are released will also receive fin clips and/or passive integrative transponder (PIT) tags to monitor site fidelity (except for those that are sacrificed). Following gastric lavage and recovery, predators will be returned immediately to their place of capture. Stomach contents will be preserved in alcohol, and stored in individually-labeled whirlpacks or sample jars. Stomach contents will be identified to the lowest taxanomic level possible and measured for standard, fork, and total length (mm).

Site-specific releases of marked juvenile Chinook salmon will be varied temporally to allow for recolonization of predators at the release sites. For 2017, sampling will be conducted at Reclamation's Emmaton and Antioch sites (Figure 1) once each during early to mid-April, and return to sample each site once again in early to mid-May. In 2018 and 2019, if the pilot study is successful, sampling may extend to CDWR's new release sites at Curtis Landing, Manzo Ranch, and Little Baja, which are all on Sherman Island (Figure 1). Each sampling event will follow the same protocols listed above. To summarize, there will be a total of four sampling events in 2017, 2018, and 2019: one 8-hr sampling event at each release site during April and one 8-hr sampling event during May for a total of 32 hours. The release site locations and timing may vary in 2018 and 2019, but the total sample time will be the same (*i.e.*, 32 hours total or 2 sampling events at 2 sites per year including March).

An estimate of juvenile Chinook salmon predation loss at multiple release sites will be conducted by releasing a known number of photonically-marked juveniles (hatchery produced) during a normal fish release event. These marked fish will be added to the daily salvaged fish in the tanker truck prior to release through the release pipe. 1,000 juvenile Chinook salmon (fall-run) will be obtained from a California state fish hatchery in early 2017 for use in this study. By using the normal fish salvage releases, the study will be considered representative of the fish densities, species, and size-classes of fish typically encountered at that time of year. Following release, the marked juvenile salmon will be given one hour to interact with predators, after which trammel nets will be deployed to capture predators.

Water temperature plays an important role in the mortality of fish that are entangled in nets. As water temperature rises, it puts more stress on the capacity of captured fish to withstand handling. Therefore, based on studies in the literature (Cech and Crocker 2002; Kahn and Mohead 2010), the trammel nets will not be deployed when water temperatures exceed 25^{o}C or dissolved oxygen (DO) falls below 5 milligrams/liter (mg/l).

Each trammel net will be fished twice at each site over two months for a total of 4 sampling events over the length of the pilot study in 2017. Total time for the trammel nets in the water is 32 hours. If the pilot study is successful, trammel net sampling would be continued in 2018, and 2019. The nets will be checked every two hours or when movement of buoys indicate fish are being caught, whichever comes first, by a crew of two to three Reclamation biologists in a chase boat. The nets will be retrieved sooner than the 2-hour soak time if the float line and/or buoys indicate excessive loads of entangled fish or debris. Therefore, the net will be monitored for activity during the entire 8 hour period. All captured fish will be processed and all ESA-fish will be released immediately away from the nets following a recovery period in the holding pens. Once the nets are cleared, they will be returned to the water to continue fishing during the 8-hour period.

Captured fish displaying any of the following behaviors will be resuscitated and held (short-term) prior to release in in-water net pens: (1) extreme lethargy, (2) excessive respiration rate (compared to cohorts), (3) inability to maintain upright position in the water column (loss of equilibrium). Resuscitation protocol will include maintaining fish in an upright position (state of equilibrium) in the water column while gently moving them in a fashion to permit water to continually flow across their gills. Following resuscitation, fish that maintain equilibrium and display strong swimming ability (significant efforts to swim from handling position) will be released. Fish that do not display strong swimming characteristics, but maintain equilibrium in the water column, will stay in the floating net pen and monitored until they appear to have fully recovered from capture and handling. Reclamation intends to follow the procedure in use by the CDFW steelhead monitoring program (NMFS 2015a) where applicable.

B. Freshwater and Marine Mammals

Freshwater and marine mammals are known to occur in the action area. Predators such as river otters (*Lutra canadensis*), and pinnipeds, including harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) occur in the Delta waterways. River otters are endemic to the Delta and are known to be capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993). Although harbor seal and sea lion predation primarily is confined to the marine and estuarine environments, they are known to travel well into freshwater after migrating fish and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin rivers. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable, such as the large water diversions in the South Delta or where fish are captured in fishing gear such as nets. Predators can remove fish from the mesh of the nets after they are caught (depredation mortality), chase fish that are obstructed by the net deployment (predation mortality) from their normal movements, or are captured by predators after they are discarded from the fishing operation as discarded bycatch (predation mortality) (Raby *et al*. 2014, Uhlmann and Broadhurst 2015). Stress and injury from the process of being captured in the net and either escaping the net or being returned to the water as discarded bycatch can temporarily impair physiological capacity and alter behavioral responses to predators in released animals, a period during which predation risk is likely elevated (Raby *et al*. 2014).

Predators are attracted to the areas where "easy" prey is available. Prior to deployment of the fishing gears used in the Project, crews will patrol 0.5 kilometers (km, 0.31 miles) upstream and downstream of the fishing site looking for marine mammals. If marine mammals are observed during this patrol, nets will not be deployed until the animals have cleared the area. Implementation of this reconnaissance measure should reduce the probability of contact between the fishing operations, impacted fish, and the mammalian predators.

1.3.1 Additional Equipment

On February 13, 2017, Reclamation sent a supplement to the BA which added monitoring equipment and extended the study to 2019. The additional equipment consists of newly developed predator-detection acoustic tags (PDAT) that can tell when a fish is preyed upon. They also expanded the Project area to include two new release sites at the SWP and the installation of an acoustic arrays (receivers/hydrophones) across the Sacramento River at Rio Vista and Sherman Island (Figure 2).

Figure 2. Expanded Project area including location of hydrophones (acoustic receiver arrays) at the Emmaton release site.

Reclamation proposes the use of VEMCO (https://vemco.com) acoustic transmitters (version V5 and V5-predation detection tags) in order to track hatchery Chinook salmon released from the CVP and SWP release pipes. Acoustic tags will be surgically inserted into juvenile hatchery salmon at the TFCF two 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 which 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 then be tied 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 anticipates the placement of 14-20 hydrophones for 2017 (Figure 2), and up to 40 hydrophones in 2018 and 2019. For 2017, the hydrophones will be placed in the water on or around May 15, and removed on or around May 21. Hydrophone placement in 2018 and 2019 will likely occur in March and May in similar locations, and possibly at other release sites.

C. 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 study (*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).

D. Requested Amount of Incidental Take

The requested amount of incidental take presented in Table 1, is the minimum estimated amount of take necessary to achieve the goals and objectives of the proposed Project.

Table 1. Summary of requested incidental take (Reclamation 2016).

ESA-listed species	**Life-stage**	**Incidental Mortality**	**Harm or Harass**	**Proposed Action**	**Method**
Winter-run Chinook	Adult	0	0	Capture/Handle/ Release Fish	Trammel Net
Winter-run Chinook	Juvenile	0	0		
CV Spring-run Chinook	Adult	0	1	Capture/Handle/ Release Fish	Trammel Net
CV Spring-run Chinook	Juvenile	0	0		
CCV steelhead	Adult	0	1	Capture/Handle/ Release Fish	Trammel Net
CCV steelhead	Juvenile	0	0		
CCC steelhead	Adult	0	0	Capture/Handle/ Release Fish	Trammel Net
CCC steelhead	Juvenile	0	0		
sDPS green sturgeon	Adult	0	0	Capture/Handle/ Release Fish	Trammel Net
sDPS green sturgeon	Juvenile	0	0		

1.4 Conservation Measures

Measures to reduce stress and handling of fish:

- Fish sampling will be performed by Reclamation’s qualified fish biologists.

- Biologists will check the trammel nets every 2 hours, or when movement of buoys indicate fish are being caught, whichever comes first. Fish will be removed as soon as signs of entanglement are noticed.
- Biologists will monitor water temperatures and DO near the release sites. The trammel nets will not be deployed if water temperature exceeds 25°C, or DO falls below 5 mg/l (or 58 percent saturation using YSI water quality meter).
- Biologists will monitor the area prior to deploying nets to ensure that marine mammals are not present. If marine mammals are observed within approximately 0.5 km (0.31 miles) of the nets, they will not be deployed until the animals have cleared the area.
- Captured fish displaying signs of stress will be resuscitated and monitored for recovery in floating net pens before release.
- All ESA-listed species (including non-listed Chinook salmon) incidentally caught will be removed from the net, held for recovery in the net pens, and then returned to the water.
- Dead or injured ESA-listed fish and any marine mammals caught in the net will be reported immediately to NMFS, USFWS, and CDFW.

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 Incidental Take Statement (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.

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 Project. 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). Gear selectivity for these monitoring locations may preclude the presence of certain species like sDPS green sturgeon in the trawl data because they are typically found near the bottom.

2.2 Rangewide Status of the Species and Critical Habitat

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

2.2.1 Sacramento River Winter-run Chinook Salmon

- 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).
- Designated critical habitat (June 16, 1993, 58 FR 33212).

The Federally listed evolutionarily significant unit (ESU) of Sacramento River winter-run Chinook salmon (winter-run) and designated critical habitat for this ESU occurs in the action area and may be affected by the proposed action. Detailed information regarding ESU listing and critical habitat designation history, description of designated critical habitat, 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 (CDFG 1975–2016). 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 1975–2016). 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 RBDD was approximately 5 and 4 percent, respectively (Williams *et al*. 2016). Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled (*i.e*., 612,056 released) to offset the impact of the drought (State Water Resources Control Board 2014). In 2014, hatchery production represented 83 percent of the total in-river juvenile production. 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 in 2016 were 1,546 and are expected to be low in 2017, as they were impacted by drought conditions on juveniles from brood years 2014 and 2015 (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 and 2015, 612,056 and 420,000 hatchery winter-run were released, respectively, which means that 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 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. 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).

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

The critical habitat designation for winter-run lists the PBFs (June 16, 1993, 58 FR 33212, 33216-33217), which are described in NMFS (2014). This designation includes the following waterways, bottom and water of the waterways and adjacent riparian zones: the Sacramento River from Keswick Dam [river mile (RM) 302] to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta); all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge (June 16, 1993, 58 FR 33212). NMFS clarified that “adjacent riparian zones” are limited to only those areas above a stream bank that provide cover and shade to the near shore aquatic areas (June 16, 1993, 58 FR 33212). Although the bypasses (*e.g.*, Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run use the tributaries of the Sacramento River for non-natal rearing (Maslin *et al.* 1997, PSMFC 2014).

2.2.1.3 Summary of the Value of Sacramento River Winter-run Chinook Salmon Critical Habitat for the Conservation of the Species

Currently, many of the PBFs of winter-run critical habitat are degraded, and provide limited high quality habitat. Features that lessen the quality of migratory corridors for juveniles include unscreened diversions, altered flows in the Delta, and the lack of floodplain habitat. In addition, water operations that limit the extent of cold water below Shasta and Keswick dams have reduced the available spawning habitat (based on water temperature). Although the current conditions of winter-run critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain are considered to have high intrinsic value for the conservation of the species.

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).
- Designated critical habitat (September 2, 2005, 70 FR 52488)

The Federally listed ESU of CV spring-run and designated critical habitat for this ESU occurs in the action area and may be affected by the proposed action. Detailed information regarding ESU listing and critical habitat designation history, description of designated critical habitat, 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 (CDFG 1975-2016). 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 the CV spring-run ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance (NMFS 2011a, NMFS 2016). 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 (TRT) 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 2013).

The CV spring-run ESU 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 the fall-run ESU (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 two to three years as opposed to waiting another five 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 2016) found the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality reaching record lows. 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 2016).

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 the CV spring-run ESU remains at moderate risk of extinction (NMFS 2016). 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 2016).

2.2.2.2 Critical Habitat and Physical or Biological Features for CV Spring-run

The critical habitat designation for CV spring-run lists the PBFs (June 28, 2005, 70 FR 37160), which are described in NMFS (2014). In summary, the PBFs include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat. The geographical range of designated critical habitat includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta (June 28, 2005, 70 FR 37160).

2.2.2.3 Summary of the Value of CV Spring-run Critical Habitat for the Conservation of the Species

Currently, many of the PBFs of CV spring-run critical habitat are degraded, and provide limited high quality habitat. Features that lessen the quality of migratory corridors for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta, scarcity of complex in-river cover, and the lack of floodplain habitat. Although the current conditions of CV spring-run critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain are considered to have high intrinsic value for the conservation of the species.

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).
- Designated critical habitat (September 2, 2005, 70 FR 52488).

The Federally listed distinct population segment (DPS) of CCV steelhead and designated critical habitat for this DPS occurs in the action area and may be affected by the proposed action. Detailed information regarding DPS listing and critical habitat designation history, description of designated critical habitat, 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 (NFH) have increased over the last four years, 2011 to 2014 (NMFS 2016a). After hitting a low of only 790 fish in 2010, the last two 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 2015).

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, NMFS 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, NMFS 2011b, NMFS 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).

2.2.3.2 Critical Habitat and Physical or Biological Features for California Central Valley Steelhead

The critical habitat designation for CCV steelhead lists the PBFs (June 28, 2005, 70 FR 37160), which are described in (NMFS 2014). In summary, the PBFs include freshwater spawning sites; freshwater rearing sites; freshwater migration corridors; and estuarine areas. The geographical extent of designated critical habitat includes: the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River above the Merced River confluence; and the waterways of the Delta.

2.2.3.3 Summary of the Value of California Central Valley Steelhead Critical Habitat for the Conservation of the Species

Many of the PBFs of CCV steelhead critical habitat are currently degraded and provide limited high quality habitat. Passage to historical spawning and juvenile rearing habitat has been largely reduced due to construction of dams throughout the Central Valley. Levee construction has also degraded the value for the conservation of the species of freshwater rearing and migration habitat and estuarine areas as riparian vegetation has been removed, reducing habitat complexity, food resources, and resulting in many other ecological effects. Contaminant loading and poor water quality in Central California waterways poses threats to lotic fish, their habitat and food resources. Additionally, due to reduced access to historical habitats, genetic introgression is occurring because naturally-produced fish are interacting with hatchery-produced fish which has the potential to reduce the long-term fitness and survival of this species.

Although the current conditions of CCV steelhead critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento/San Joaquin River watersheds and the Delta are considered to have high intrinsic value for the conservation of the species as they are critical to ongoing recovery efforts.

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

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

The Federally listed sDPS green sturgeon and designated critical habitat for this DPS occurs in the action area and may be affected by the proposed action. Detailed information regarding DPS listing and critical habitat designation history, designated critical habitat, 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 2007). 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 (Isreal *et al*. 2009, Cramer Fish Sciences 2011, Seeholtz *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 the sDPS is composed of a single, independent population, which principally spawns in the mainstem Sacramento River and also breeds opportunistically in the Feather River and possibly even the Yuba River (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 2010). 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 *et al.* 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 2010). Although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2010). 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).

2.2.4.2 Critical Habitat and Physical or Biological Features for sDPS Green Sturgeon

The critical habitat designation for sDPS green sturgeon lists and describes the PBFs (October 9, 2009, 74 FR 52300). In summary, the PBFs include the following for both freshwater riverine systems and estuarine habitats: food resources, water flow, water quality, migratory corridor, depth, and sediment quality. Additionally, for riverine systems, the designation includes substrate type or size. Substrate type or size is also a PBF for freshwater riverine systems. In addition, the PBFs include migratory corridor, water quality, and food resources in nearshore coastal marine areas. The geographical range of designated critical habitat includes the following.

In freshwater, the geographical range includes:

- the Sacramento River from the Sacramento I-Street bridge to Keswick Dam, including the Sutter and Yolo bypasses and the lower American River from the confluence with the mainstem Sacramento River upstream to the highway 160 bridge,
- the Feather River from its confluence with the Sacramento River upstream to Fish Barrier Dam,
- the Yuba River from its confluence with the Feather River upstream to Daguerre Point Dam, and
- the Sacramento-San Joaquin Delta (as defined by California Water Code section 12220, except for listed excluded areas).

In coastal bays and estuaries, the geographical range includes:

- San Francisco, San Pablo, Suisun, and Humboldt bays in California,
- Coos, Winchester, Yaquina, and Nehalem bays in Oregon,
- Willapa Bay and Grays Harbor in Washington, and
- the lower Columbia River estuary from the mouth to river kilometer 74.

In coastal marine waters, the geographical range includes all U.S. coastal marine waters out to the 60-fathom depth bathymetry line from Monterey Bay north and east to include waters in the Strait of Juan de Fuca, Washington.

2.2.4.3 Summary of the Value of sDPS Green Sturgeon Critical Habitat for the Conservation of the Species

Currently, many of the PBFs of sDPS green sturgeon are degraded and provide limited high quality habitat. Additional features that lessen the quality of migratory corridors for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta, and presence of contaminants in sediment. Although the current conditions of green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in both the Sacramento/San Joaquin River watersheds, the Delta, and nearshore coastal areas are considered to have high intrinsic value for the conservation of the species.

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 Sherman Island for a distance of 200 yards in front of the release sites and 6 miles upstream on the Sacramento River to the Rio Vista Bridge. Multiple release sites will be used, including Curtis Landing and Antioch on the San Joaquin River, and Emmaton, Manzo Ranch, and Little Baja on the Sacramento River (Figure 3). 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 vicinity of the proposed Project 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 all release site locations.

Winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon have the potential to occur in the action area during the proposed study periods in 2017, 2018, and 2019. Within the action area, designated critical habitats occurs in the Sacramento River for winter-run, CV spring-run, CCV steelhead, and the sDPS green sturgeon. Within the San Joaquin River, designated critical habitat for CCV steelhead and sPDS green sturgeon occurs in the action area (Figure 3).

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). This freshwater to low salinity estuarine habitat provides critical habitat for winter-run, CV spring-run, CCV steelhead and sDPS green sturgeon.

The principal water bodies near the project area include the Sacramento River and the San Joaquin River. All of 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 salt water 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% of seasonal wetlands and 94-98% of riparian forests in the Central Valley (Wipple *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).

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.

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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.

2.4.1 Status of the Species within the Action Area (March 1 through May 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. Generally, as flows increase in the fall, adult salmon, CCV steelhead, and sDPS green sturgeon migrate upstream through the Sacramento and San Joaquin rivers and juveniles migrate downstream in the winter and spring. Adult CCV steelhead migration typically begins in August and extends through the winter to as late as May (Table 2). 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 between January and June (Table 4) and adult green sturgeon start to migrate upstream in February and can extend into July (Table 5).

2.4.1.1 CCV Steelhead

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 2), 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.*, 30–50 mm) are captured at the Oakdale RST on the Stanislaus River starting as early as April and continuing through June (FishBio 2012).

Table 2. Temporal occurrence of CCV steelhead in the Delta**.**

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SH*	■	■	■	■	■			■	■	■	■	■
Juvenile SH**		■	■	■	■	■						

*Adult presence was determined using information in (Moyle 2002), (Hallock *et al.* 1961), and (CDFW 2007).
**Juvenile presence in the Delta was determined using DJFMP data and (Hallock *et al.* 1961).

2.4.1.2 Winter-run Chinook salmon

Adult winter-run are expected to be in the action area in April and May (Table 3) as they migrate upstream to spawn in the upper Sacramento River. For juvenile winter-run, a review of fish monitoring data from 2009–2013 in and around Sherman Island showed low numbers present in April and none in May (USFWS 2015a). 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). 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).

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

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult WR*	■	■	■	■	■	■					■	■
Juvenile WR**	■	■	■	■							■	■

*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).
**Juvenile presence in the Delta was determined using DJFMP data.

2.4.1.3 CV spring-run Chinook salmon

Adult CV spring-run are expected to be migrating upstream through the action area in April and May (Table 4). Juvenile CV spring-run are also likely to be present as they migrate to the ocean in the spring. As with winter-run, adult CV spring-run are expected to be migrating through the action area during the proposed Project. Adult CV spring-run could stray around Sherman Island and be captured in trammel nets. For juvenile CV spring-run, a review of the CDFW mid-water trawl data for Stations 837 and 853, located near the Project, showed 16 juvenile Chinook salmon were caught from 2009–2013; however, these fish were not identified to run (CDFW 2015).

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

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SR*	■	■	■	■	■	■						
Juvenile SR**	■	■	■	■	■							■

*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).
**Juvenile presence in the Delta was determined using DJFMP data.

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 5). Green sturgeon numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981–2015, green sturgeon may be present during any month of the year, but only a few juveniles have been observed since 2011. The average size of salvaged green sturgeon is 330 mm (range 136 mm–774 mm). The size range indicates that these are sub-adults rather than adult or larval/juvenile fish. These sub-adult fish likely utilize the Delta for rearing for a period of up to approximately 3 years. Observations of sport caught green sturgeon in the San Joaquin River indicate that sub-adult green sturgeon have a strong potential to be present within the action area during the March through May field season (CDFW 2011, 2014; 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 5. Temporal occurrence of sDPS green sturgeon in the Delta.

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult GS*												
Juvenile GS**												

*Adult presence was determined to be year round according to information in (CDFW 2008-2014), (Heublein *et al.* 2008), and (Moyle 2002).

**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).

2.4.2 Condition of Critical Habitat within the Action Area

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

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

Even though the Delta habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high. The NMFS ESA-listed species must pass through and utilize this area on their way to or from the spawning grounds. Therefore, it is of critical importance to the long-term viability of the species to maintain a functional migratory corridor and freshwater rearing habitat within the action area. The NMFS recovery plan considers the Delta to be a top priority for restoration of ecological functions to support native species and increase their long term health and resilience (NMFS 2014).

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

The general condition and function of habitat within the action area has already been described in the *Status of the Species and Critical Habitat* (section 2.2) of this Opinion. The substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. Within the action area, the banks have been heavily rip-rapped with rock slope protection on artificial levee banks. The extensive riprapping and levee construction has precluded natural river channel migrations and the formation of riffle pool configurations in the Delta's channels. Natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been cleared for farming. A small fraction of the historical wetlands exists within the action area at Sherman Island Lake (flooded interior of the island when due to levee failure). Little riparian vegetation remains in the south Delta, except for tules growing along the foot of the levee banks. Numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (*i.e.*, Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, *etc*.). These artificial channels have disturbed the natural flow of water through the south Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment.

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

2.4.3 Effects of Global Climate Change in the Action Area

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

Sea levels are expected to rise by 0.5 m to 1.0 m along the Pacific coast in the next century (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) affecting salmonid and green sturgeon PBFs 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, and destroy fish and wildlife habitat, including salmon-spawning streams.

Droughts along the West Coast and in the interior Central Valley of California are already occurring and likely to increase with climate change. This means decreased groundwater storage and stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water 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, Dettinger 2005, and 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 2012–2015, 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 2017 and 2018, 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 May (Table 6). NMFS conducted a review of nearby CDFW monitoring locations, run timing, and fish salvage data to determine the likelihood of ESA-listed fish presence (Tables 2-5). 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 6. Presence of ESA-listed species in the action area (NMFS 2016, CDFW 2016). For CCV steelhead, presence includes kelts migrating downstream after spawning.

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

2.5.1 Fishing Gear Effects

2.5.1.1 DIDSON camera

DIDSON 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 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*. 2010); and to study fish behavior under a variety of conditions (*e.g.,* 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 (Hastings and Popper 2005). 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 not expected to harm fish released from the salvage facilities or any fish in the action area.

2.5.1.2 Photonic Marking

The use of photonic marks is a method of marking fish 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. Photonic paint (*i.e.,* polymethylacrylate fluorescent pigment encapsulated in latex microspheres) has been developed for use in pressurized marking guns to rapidly mark large numbers of fish at low cost. 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, Mohler *et al*. 2002, Reclamation 2008, Catalano *et al.* 2011, and Castillo *et al.* 2014).

2.5.1.3 Effects on the Fish Salvage Process

Reclamation proposes to inject photonic marks into hatchery juvenile Chinook salmon and then release these fish with the normal fish salvage facility releases. The marked salmon will mix with other fish in the transport truck and going through the release pipe. Since there should not be a difference in predation rates between the marked fish and unmarked fish (*i.e.,* marked fish are similar in size to salvaged fish at that time of year, Figure 4), the number of marked fish recovered in the diet of the predators should allow for quantification of predation rates at the release sites. Since ESA-listed species are not proposed for marking, there will not be any negative impacts of the marking to listed species. The only impact to listed species may come from the mixing of marked salmon into the normal fish salvage process. The collection, handling, trucking, and release of salvaged fish is considered in the NMFS 2009 Opinion. However, the salvage process may be delayed from the addition of marked fish to the tanker trucks. Any delay experienced loading the marked hatchery fish is not anticipated to harm ESA-listed fish since the fish in the holding tanks are typically held for 24 hours prior to trucking to the release sites (trucks make 1-2 trips/day depending on the presence of ESA-listed fish). When fish are crowded together in holding tanks, trucks, or traps, size-dependent predation can be an issue. Marked hatchery salmon may prey on smaller size ESA-listed species (*e.g*., juvenile salmon). However, during the proposed April through May study period, the size of any natural juvenile winter-run or CV spring-run would be larger than the marked hatchery raised fall-run Chinook (Table 7), since fall-run spawn later in time (Fisher 1992). Steelhead smolts consistently average 250 mm when pass through the Delta (CDFW 2016). Since steelhead smolts are larger than the marked hatchery Chinook salmon, it is unlikely that they would experience any predation from the marked hatchery salmon. Based on the growth rates for the different races, it is unlikely that the marked study fish would be large enough to prey on any ESA-listed salmonids (Table 7).

Table 7. Juvenile salmon length-at-date (mm) in April and May based on growth rates from the Delta model (Fisher 1992) compared to marked study fish. CCV steelhead size based on fish salvage data (CDFW 2016, CDWR 2016).

Salmon and steelhead sizes	April (minimum FL)	May (maximum FL)
Winter-run	99	220
CV spring-run	73	136
salvaged salmon	34	110
Fall-run (marked study fish)	34	99
CCV steelhead	250	250

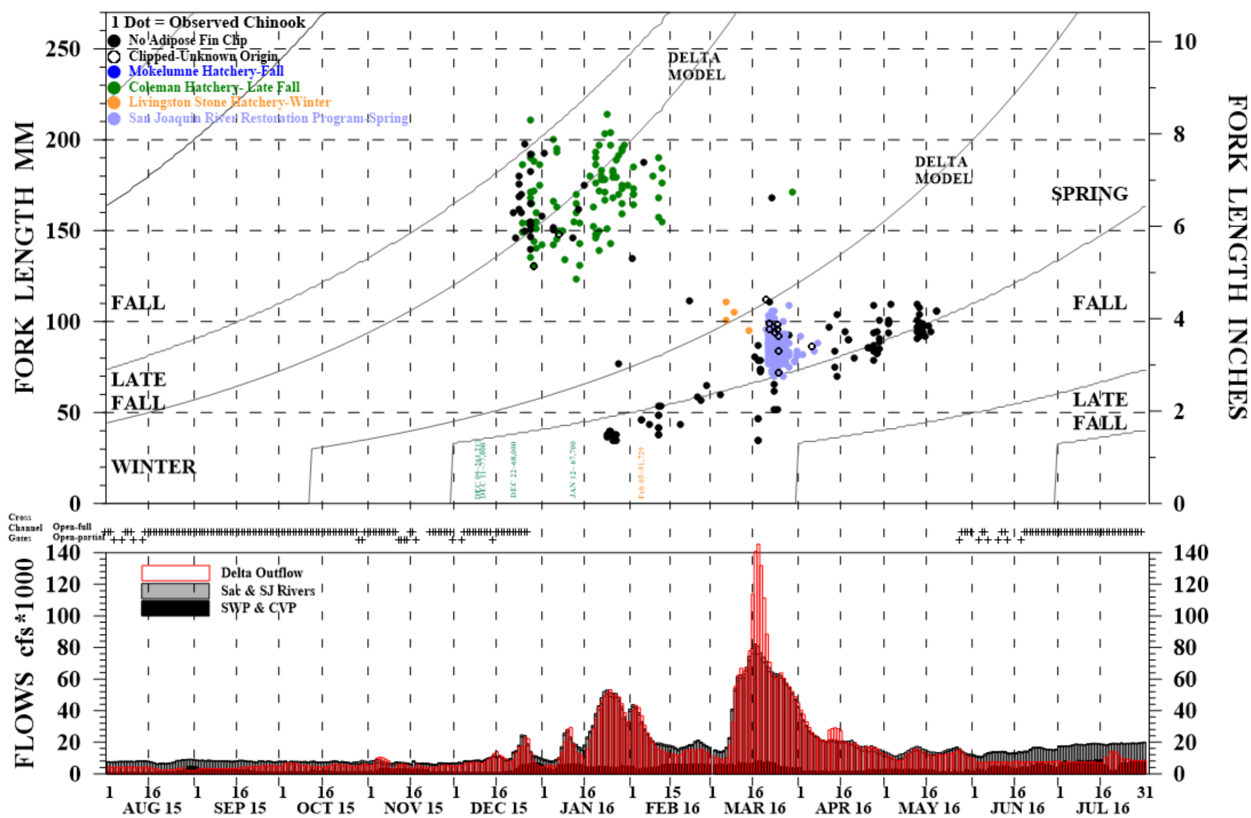

Figure 4. Observed Chinook salvage at the Delta fish facilities, with Delta hydrology, August 1, 2015, through July 31, 2016. Chinook salmon race/run designation is based on Delta model and CWT recoveries (CDWR 2016).

2.5.1.4 Trammel nets

Trammel nets are commonly used in fisheries to selectively target larger fish (Figure 5). A trammel net is similar to a gill net except that it has panels which allow smaller fish such as juvenile Chinook salmon to pass through. Gill nets have been used for years to capture and release sturgeon in San Pablo Bay, and are used in the Delta (*i.e.*, Montezuma Slough) to capture and release adult salmon after tagging. However, unlike a gill net, the trammel net does not catch the fish by the gills. As long as trammel nets are monitored closely, captured fish can be released alive. A trammel net consists of two/three layers of netting with a slack small mesh inner netting between two layers of large mesh netting within which fish will entangle. These nets are strings of single, double or triple netting walls kept more or less vertical by floats on the head rope and by a weighed lead line on the bottom (Figure 5).

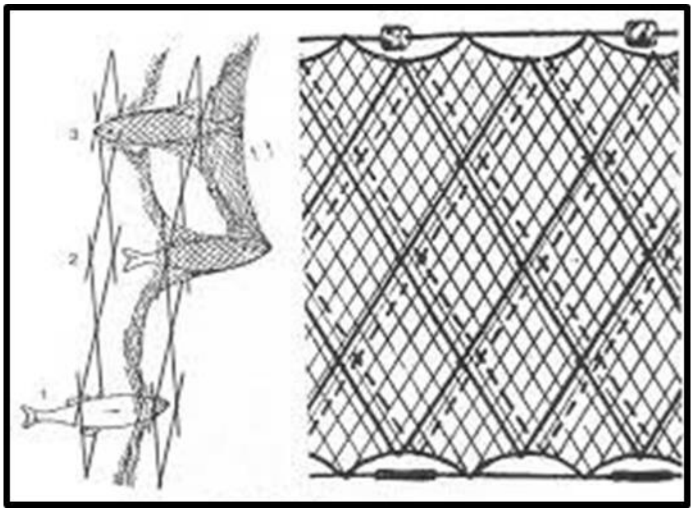

Figure 5. Drawing of a trammel net depicting how it remains vertical in the water column allowing fish to become entangled in a bag of mesh with minimal injuries.

Reclamation proposes to use 4 trammel nets that are 100 feet long, and either 6 or 12 feet in depth. Each net is made up of a two 10-inch square outer layers with 2.5 inch square multi-inner mesh layer. The 2.5 inch square multi-inner mesh on the trammel net will allow most of the smaller salvaged fish from the Fish Facilities to pass through, while the larger predators such as striped bass, largemouth bass, and Sacramento pikeminnow (*Ptychocheilus grandis*) will become entangled. Fish of sufficient size that encounter the trammel net will disrupt the floating buoy line and will be detected immediately by the crew on site as a result of the disruption of the floating buoys attached to the headline. This allows rapid recovery and removal of the entangled fish.

Trammel nets have the potential to capture adult salmon, steelhead, or green sturgeon that may be in the area. However, the potential to capture ESA-listed salmonids and green sturgeon is low since they tend to stay in the deeper main channels as they migrate upstream or downstream (Beccio 2017). The trammel nets will be placed close to shore in shallow water near the outlet of the release pipes. The conservation measures incorporated in the Project will reduce the potential for direct mortality. Frequent net checks every 2 hours, or when movement of buoys indicate fish are being caught, whichever comes first, resuscitation methods, and recovery in holding pens should reduce the chance of mortality. At no time will soak times be longer than 2 hours, and nets will not be deployed when water temperature exceeds 25ºC, or DO falls below 5 mg/l or 58 percent of saturation.

Any time fish become entangled in a net they are stressed from the ordeal. Adult sturgeon tend to roll up in nets and can suffocate in a short time from the net wrapped around their gills. Adult salmon caught around their gills and can expire quickly unless removed immediately. After being released, salmon tend to hold/sulk before continuing their upstream migration and may be delayed for a period of days to weeks. A delay in reaching the spawning grounds can reduce the chance of finding a mate or shorten the egg incubation period if they arrive late. Eggs that hatch late are less likely to survive (*i.e*., eggs can be damaged by removing fish from the net, or experience warmer water temperature if spawning is delayed). Fish that escape from entanglement or are released alive often show higher rates of pre-spawn mortality from injury or the stress of being captured, handled, and released (Baker 2009).

Other predators such as harbor seals, California sea lions, and river otters are attracted to fish caught in nets and can quickly injure or remove an entangled fish. California sea lions are known to travel far upstream into freshwater, following adult salmon, and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin rivers. Seals have been observed to herd fish towards a stationary fish screen (*e.g.*, Rock Slough Fish Screen, CVP and SWP Fish Salvage Facilities) in the Delta so that they have an easier chance of capturing prey. Predation can be a greater factor when prey populations are low such as in ESA-listed species. Chasco *et al*. (2017) found the increasing abundance of pinnipeds along the West Coast may adversely affect the recovery of ESA-listed Chinook salmon. Stress and injury to fish from being captured in the net and either escaping the net, or being returned to the water, can temporarily impair their physiological capacity, making it easier for opportunistic predators to catch them.

Prior to deployment of the fishing gears used in the Project, crews will patrol 0.5 km (0.31 miles) upstream and downstream of the fishing site looking for marine mammals. If marine mammals are observed during this patrol, nets will not be deployed until the animals have cleared the area. Implementation of this reconnaissance measure should reduce the probability of contact between the fishing operations, impacted fish, and the mammalian predators (Reclamation 2016).

Vander Haegen *et al.* (2004) estimated that adult spring-run captured in the lower Columbia River below Bonneville Dam by gill nets and tangle nets had an immediate survival rate greater than 95 percent. Vander Haegen *et al*. (2004) also describes the bycatch of several other species of fish, including sturgeon (not identified as white or green sturgeon, but most likely white sturgeon based on location) and steelhead. Sturgeon were reported to be released in generally "good condition" while the condition of other species was variable. In the two years of studies, 77 steelhead were captured, and they were all reported as released in "good condition."

Trammel nets catch smaller fish than other fishing gear such as gill nets, and survival of captured fish is influenced by water temperatures and duration of soak times for the nets. Studies targeting sturgeon indicate that sturgeon were susceptible to a wide range of mesh sizes because of their behavior of rolling in the nets upon capture and entangling their scutes and rostrum in the mesh of the net, regardless of mesh size (Doyle *et al*. 2008, Wanner *et al*. 2007). Other fish were frequently found in gill nets with larger mesh sizes. Therefore, there is the potential for juvenile fish to become entangled with the larger, targeted fish. This potentially could result in injury or mortality for smaller fish, including juvenile salmon, juvenile green sturgeon, and steelhead smolts.

As water temperature increases, the physiological capacity of the captured fish to withstand the multiple stressors associated with capture is reduced – the fish is less resilient to the process of capture and may die as a result. Cooler waters reduce the stress level and enhance survival through better oxygen uptake and more favorable metabolic conditions, allowing better survival in the net and quicker recovery post release. Warmer water has lower DO content that leads to more hypoxia in trapped fish struggling against entanglement. During the proposed study period of April to May in 2017, and March through May in 2018 and 2019, ambient water temperatures in the Delta near Sherman Island fluctuate between 13.3°C (56°F) and 21.1°C (70°F). Water temperatures in 2016 were similar to the previous 7 years and below 20°C (68°F) at the Antioch Fish Release Site until the middle of May (Figure 6). The health and survival of fish captured in the trammel nets is expected to improve substantially when ambient water temperatures are below 20°C. Water temperatures above 20°C are stressful to salmonids, leading to depressed physiological function, increased oxygen utilization, and delayed recovery. At water temperatures above 20°C the additional stress of capture in the nets will lead to increased incidence of mortality from the combined effects of capture and thermal stress.

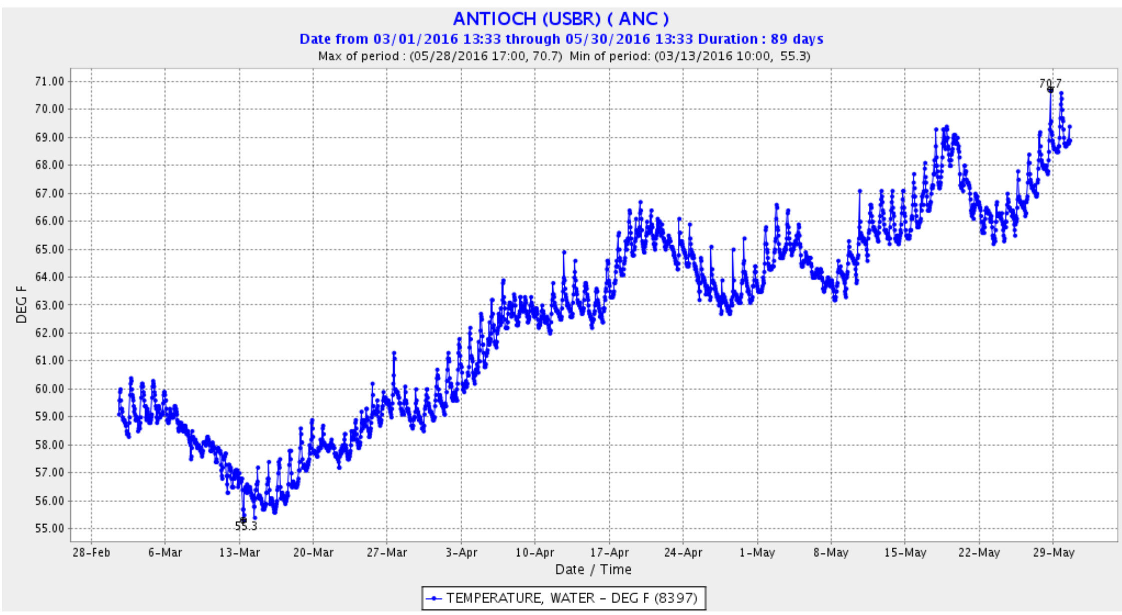

Figure 6. Antioch water temperatures February-May 2016 (Reclamation 2017)

The project description has indicated that a boat and crew will frequently check the stationary trammel net, and trammel nets will not be deployed when water temperatures exceed 25°C (77°F), or DO falls below 5 mg/l, or 58 percent of saturation as determined by using YSI water quality meters (Reclamation 2016). NMFS anticipates that based on the literature, captured fish could be stressed, killed, or experience post-capture mortality at water temperatures from 20 to 25°C. Green sturgeon mortalities have been documented in the empirical records of researchers while fishing above 20°C at net set durations ranging from 45 minutes to 24 hours (Kahn and Mohead 2010). However, mortalities have been extremely rare when fishing nets less than two hours and at temperatures between 20° and 25°C.

For green sturgeon, Kahn and Mohead (2010) recommend that gill net fishing not be conducted in the Sacramento River all year to prevent interactions with listed salmonids and to also protect green sturgeon during their upstream migrations. In other locations, the risk of interactions between gillnets or trammel nets and listed salmonids or pinnipeds requires the nets to be manned at all times. NMFS recommends net soak times should not exceed 4 hours in water temperature up to 19°C, 2 hours between 19° and 23°C, and 1 hour for water temperature between 23° and 25°C (Table 8).

Table 8. Recommended protocols to protect green sturgeon when gill net fishing (Kahn and Mohead 2010).

Net soak times (hours)	Temperature at sampling depth	Minimum DO at sampling depth	% oxygen saturation at sampling depth
4	Up to 19°C	5 mg/l	58%
2	19°C to 23°C	5 mg/l	58%
1	23°C to 25°C	5 mg/l	58%
No netting	Over 25°C	5 mg/l	58%

Fish will be removed from the net when movement of the floating buoys on the top line indicate a fish has become entangled in the net. If any ESA-listed fish are encountered, they will be given priority for removal and resuscitated before being placed in recovery net pens and held until it is in suitable condition for release. For larger predators removed from the net, a small number (n=5) will be held for gastric lavage. Any injured fish will be placed in the recovery nets if its physical condition warrants it. Sturgeon will be placed in the recovery pens for observation prior to release. Although larger fish will be detectable by the movement of the top line buoys, it is unlikely that smaller fish (*e.g*., juvenile salmonids) will disturb the buoys sufficiently to be detected. Therefore, along with adult fish, there could be some mortality to juvenile or smaller fish captured before the 2-hour check.

2.5.1.5 Predator Tagging and Gastric Lavage Sampling

The PIT tagging of predators that are caught in the trammel nets and gastric lavage sampling is not likely to have any impact on ESA-listed fish since the predators will not be in contact with wild or hatchery listed-fish after they are removed from the nets. A small number of predators (n=5 of each species) will be sacrificed for quality control. The removal of predators from the area around the release sites is likely to have a beneficial effect by reducing the probability of predation on listed fish during future fish salvage releases).

2.5.1.6 Hydrophone

In a supplemental letter received on February 13, 2017, Reclamation described plans to deploy VEMCO hydrophones at 6 sites in the action area (Figure 2). 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 for the first time to track juvenile hatchery fish as they exit the release pipe. Reclamation proposes to deploy 14-20 hydrophones for 2017 pilot study, and 20-40 hydrophones in 2018 and 2019. 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.

Installation of the hydrophones will take place on or around May 15, and be removed on or around May 21 (6 days) in 2017. Future hydrophone placement will likely occur between March and May through 2019 in similar locations. 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.

2.5.2 Effects to Critical Habitat

In the action area, designated critical habitat for winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon is present in the Sacramento River, and for CV steelhead and sDPS green sturgeon in the San Joaquin River. The action area has been identified as having fresh water rearing and freshwater migratory PBFs and food resources. There is minimal contact with the underlying substrate from the trammel nets since they will only be deployed during the day for short periods of time (8 hours) before being retrieved. The placement of the small anchors (either cinder blocks or tripods) will temporarily impact the bottom substrate of the Sacramento River channel as well as the bottom substrate of Horseshoe Bend (near Decker Island). As described in the environment baseline (section 2.4) for winter-run, CV spring-run, CCV steelhead, and sDPS of North America green sturgeon, the channel bottom substrate is considered essential to the proper functioning of the critical habitat. The placement of the 8 anchors for the trammel nets and 20–40 anchors for the acoustic array is not likely to substantially alter or degrade the function or value of the substrate. The anchors will rest superficially on the bottom and may crush organisms immediately beneath them, but no more than anchors used by recreational fishing boats in the same area. The bottom substrate will return to an undisturbed condition within minutes of removal of the anchors. The anchors are small, approximately one foot square in area. The combined total area impacted by the anchors (trammel nets + acoustic array) is approximately 28–48 ft^2 (28-48 anchors * 1 ft^2/ anchor = 28-48 ft^2), however, the anchors will be spread out across the river channel reducing the impact in any one area.

Since the impacted substrate is very small compared to the area of the surrounding undisturbed channel bottom, the overall impact of the anchors is considered to be insignificant to the functioning of the critical habitat within the action area. In addition, the placement of the 20-40 anchors for the Project is temporary, lasting approximately 1-12 weeks prior to the removal of the anchors and ropes each season. The disturbed areas of the channel bottom is expected to be recolonized almost immediately by invertebrates from surrounding undisturbed areas upon removal of the anchors.

Fishing the trammel nets throughout a slack tide will minimize these anchors dragging across the bottom for roughly half of the time that the nets are deployed. No riparian or benthic habitat will be altered or destroyed. The trammel nets may temporarily block fish movement or feeding behavior in a small near-shore area (100 feet wide x 6-12 feet deep). Channel width is 2,884.4 feet and average depth is 26–31 feet at the Emmaton release site on the Sacramento River. Since the nets will be deployed parallel to the current, the cross-channel distance will be roughly 50 feet of the channel width, spanning about 1.73 percent (50/2,884.4=0.0173) of the river channel and less at Antioch since the river is wider there. Migratory salmon and green sturgeon are likely to go around, under, or through (if juveniles are small enough) the net. The nets will be deployed for a short period (twice at each site during two months). Each net will be in the water fishing 8 hours/day for a total of 32 hours. This short period of time that the nets are fishing is unlikely to reduce the quality of critical habitat. Disturbance from boats used to deploy the trammel nets and hydrophones is insignificant when compared to commercial shipping, levee repair work, and pile-driving activities in the same area. The thresholds used for underwater sound by NMFS and other agencies for the onset of physical injury to fish > 2 grams are peak sound pressure level = 206 decibels (dB) and cumulative sound exposure level (SEL) = 187 dB (Fisheries Hydroacoustic Working Group 2008). Based on life history stages and timing, all NMFS listed fish species would be > 2 grams by the time they reached the action area. For avoiding negative behavioral effects to fish, NMFS uses Root Mean Square pressure (RMS) = 150 dB. Background or ambient noise levels in San Francisco Bay have been measured at 130–140 dB (Caltrans 2009). Effects from the use of work boats will last for the duration of the Project (*i.e.*, 2-3 months). Acoustic effects from the use of work boats 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).

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, and CCV steelhead designated critical habitats that might impact production of forage organisms or disturb habitat complexity or composition. The trammel nets have no impacts to the PBFs for the sDPS of North American green sturgeon related to physical or biotic criteria except as a migratory corridor. The presence of the trammel nets and acoustic telemetry array will impede free migration through an insignificant portion of designated critical habitat which is considered only a temporary diminishment of the PBFs of freshwater migratory corridors. 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.

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, 2000; 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 (California Department of Finance 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 which are situated well away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation process with NMFS.

Increased urbanization is also expected to result in increased recreational activities in the 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 proposed Project is scheduled to be operated (*i.e.*, 2-3 months a year for 1-3 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 Current Conditions and Environmental Baseline

The *Status of 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, 2016, 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 April–May in 2017, and from March–May in 2018 and 2019. The effects of the trammel nets, DIDSON surveys, and hydrophones/acoustic receivers will be temporary since they will be removed immediately upon completion of the field season.

The proposed Project will result in adverse effects to winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon. NMFS expects that incidental take will occur in the form of capture, harm, and injury, including the potential for mortalities, as a result of stress or injury in the trammel nets. 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 placement of trammel nets. Therefore, deployment of this type of fishing gear has the potential to capture or harm winter-run. The operations of the 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 study fish and do not emit any sound themselves. Retrieval of the hydrophones and DIDSON cameras may cause transient noise as they are lifted from the channel bottom into the work boats, but the intensity and duration of any sounds produced are not expected to be of sufficient magnitude to cause harm or behavioral modifications to any fish in the vicinity.

Trammel nets will be deployed for 400 feet near the release site locations in April-May 2017 and March-May in 2018–2019. The trammel nets will fish for 8 hours at 2 sites for a total of 32 hours. Each net will be checked every 2 hours by trained biologists or when movement of buoys indicate fish are being caught, whichever comes first. Hatchery juvenile Chinook salmon will be tagged and released with the salvaged fish that are trucked from the Fish Salvage Facilities. ESA-listed fish that are salvaged at the Fish Facilities, or are in the immediate near-shore area, will be exposed to the fishing gear and could be harmed or captured, along with the targeted predators.

NMFS estimates that very few juvenile winter-run will be encountered since the number of salvaged winter-run in the south Delta is likely very low. Salvaged winter-run from the CVP Fish Facility has totaled less than 238 (length-at-date) per year in the last 3 years and have averaged less than 5 individuals that have been determined genetically to be winter-run (CDWR 2014-2016). Based on a total net deployment time of 32 hours (32 hrs/2,160 hrs possible in the 3-month period), this represents 1.48 percent of the time being salvaged. In a worst case scenario, if all 238 salvaged winter-run from the CVP were released during the 32-hour sampling period (*i.e*., 0.0148 x 238 fish), approximately 3.52 juvenile winter-run would be exposed to the trammel nets. This represents 0.00000346 percent (*i.e.*, 3.52/101,716) of the juvenile production estimated to have entered the Delta in 2015/2016 (CDWR 2016). It is even more unlikely that juvenile winter-run will encounter the nets 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 the trammel nets will be dependent on fish movements in the area of gear deployment. 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 to be captured. Juveniles and adults tend to be crepuscular (*i.e*., active at dawn and dusk), and they migrate mainly at night. Since the trammel nets will be fishing during the day there is less chance of exposure. Studies of juvenile hatchery Chinook salmon showed that within the Delta region, approximately 70 percent of fish movement detections occurred at night, while the remaining 30 percent of fish detections occurred during the daylight hours (Chapman *et. al* 2013). Data from the Fish Salvage Facilities (CDFW 2016) and RST locations on the Sacramento River (CDFW 1999-2015) also indicate that fish movement is more prevalent at night.

Survival of fish is caught in the trammel net will be enhanced by frequently checking the nets (every 2 hours or when fish entanglement is detected, whichever comes first) and resuscitating any ESA-listed fish. Fish that are captured in the net will be held in for recovery in holding pens before release. This should reduce the chance of delayed mortality and predation by marine mammals. However, smaller fish such as juvenile salmonids and juvenile sDPS green sturgeon may not be discovered until the section of net they are entangled in is lifted from the water after two hours. The potential for injury or mortality increases with a longer period of entanglement, and the extent of time that the fish struggles against the net. Frequent assessment of the number and type of fish caught can be used to reduce potential risks to smaller fish such as juvenile winter-run in the presence of larger predators such as striped bass, largemouth bass, and pike minnows.

The risk of predation by marine mammals, such as seals, is reduced or eliminated by patrolling the area upstream and downstream of the release site for a distance of 0.5 km (0.31 miles) before deploying the net, and removing captured fish immediately from the nets. If a marine mammal is observed, the net will not be deployed until the marine mammal has left the area. Constant attendance of the boat and crew around the deployed nets will allow the crews to continually survey the area for the presence of marine mammals during the time the net is deployed. This type of surveillance is designed to enhance the survival potential for fish captured in the trammel nets, but also serves the dual purpose of avoiding harassment or mortality of marine mammals.

In summary, a small number of winter-run may be captured or harmed as a result of deploying the trammel nets. These effects are expected to impact only a limited number of individual fish per year in 2017, 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.

2.7.4 Central Valley Spring-Run Chinook salmon

The risk to CV spring-run in relation to the effects of fishing gear is considerable higher since the Project overlaps more of their emigration timing. Both adult and juvenile CV spring-run will be present in the action area during the deployment of the trammel nets and hydrophones and thus may be exposed to the activity. The placement, operation, or retrieval of the DIDSON cameras and acoustic equipment is 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.

Based on juvenile monitoring data in the Delta (USFWS 2013, 2015a, 2016), approximately 90 percent of the juvenile CV spring-run population is expected to pass through the Delta in March, April, and May. In addition, adult CV spring-run are expected to be migrating upstream through the Delta at the same time. Therefore, there is a risk of entanglement or entrapment in trammel nets to 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 location. The exception is any juvenile CV spring-run that are salvaged will likely come in contact with the trammel nets. Based on 5 years of fish salvage data (2011–2015), the number of spring-run salvaged (identified by length-at-date) during March, April, and May averaged 3,747 per year (CDFW 2016). However, not all of these salvaged CV spring-run will be released at the study sites where the trammel nets are located. Assuming that roughly half are salvaged at each project, then 1,872 (3,747/2= 1,872) would be the total released by the CVP. This varies by month with the majority salvaged in April. However, not all of these would encounter the nets during the 2 days of sampling at each site. Typically, a truck makes a haul once or twice daily depending on the number of fish present in the holding tanks. Based on a total net deployment time of 32 hours (32 hrs/2,160 hrs possible in the 3-month period), this represents 1.48 percent of the time being salvaged. In a worst case scenario, if all 1,872 salvaged spring-run from the CVP were released during the 32-hour sampling period (*i.e*., 0.0148 x 1,872 fish), approximately 28 juvenile CV spring-run would be exposed to the trammel nets. This represents 0.0074 percent (*i.e.,* 28/3,747) of the average spring-run salvaged (both hatchery and wild) per year (2011–2015).

For adult CV spring-run that encounter the trammel nets, potential effects due to capture include: injury, mortality, delayed mortality, delayed migration, increased prespawn mortality, and increased vulnerability to predation. During the 2-3 months, trammel nets will be fished for no more than 2 hours before checking at water temperatures below 25°C based on the conservation measures. However, as water temperatures reach 20°C the stress from capture and handling increases the risk of mortality (section 2.5.1.4). Adult CV spring-run will not likely be entangled for more than a few minutes due to the constant attendance of the boat and crew watching for movement in the float line. All ESA-listed fish are to be released as quickly as possible if they are in "good shape." If a captured salmon show signs of distress or is injured or bleeding, it will be resuscitated and placed in recovery net pens until they can maintain position and breathe normally. When they have recovered sufficiently they will be returned to the river immediately adjacent to the release sites. This form of post-capture resuscitation has been shown to dramatically improve post-capture survival in salmonids (Farrell *et al.* 2001).

Deployment of the trammel nets during the day time will expose fewer CV spring-run adults and juveniles based on the expected diurnal/ nocturnal movement behavior mentioned above under winter-run. Juvenile young-of-the-year (YOY) spring-run that are actively migrating through the Delta are expected to pass easily through the trammel net's 10-inch square and 2.5-inch square mesh based on their smaller size (Table 7), and thus incur less injury and mortality due to entanglement or entrapment. Larger, yearling-sized spring-run may be more susceptible to entanglement and entrapment, however, they typically migrate in the winter (November–January), and therefore, not expected to be in the action area during the Project.

In summary, a small number of CV spring-run may be captured or harmed as a result of deploying the trammel nets. These effects are expected to impact only a limited number of individual fish per year in 2017, 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 deployment of the trammel nets and hydrophones throughout the Project (April to May in 2017, and March to May in 2018 and 2019). For the same reasons previously explained for winter-run and CV spring-run, operation of the trammel nets is likely to result in negative effects CCV steelhead within the action area. As described above, the deployment, retrieval and operation of the hydrophones and DIDSON cameras 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* 2015). These adult steelhead that have spawned (kelts) and migrate downstream are in poor condition and less likely to avoid the trammel nets (Teo *et. al* 2011). Although the average size of CCV steelhead is typically smaller than adult Chinook salmon, steelhead adults are expected to experience similar negative effects from entanglement in trammel nets, including delays in migration due to entanglement or entrapment, injury, immediate mortality, or delayed mortality after the fish is released. The small size of the mesh (2.5-inch square) will intercept any adult CCV steelhead that attempt to pass through the mesh. Similar to adult Chinook salmon, adult CCV steelhead will likely become entangled in the trammel net by the fish wrapping itself in the interior netting mesh, or by wedging or gilling itself in the outer net walls.

Trammel nets will be fished no more than 2 hours before being checked. Based on expected water temperatures between 20^{o}C and 25^{o}C, any CCV steelhead caught in the trammel net are expected to be stressed, but are likely to survive after a short recovery time (section 2.5.1.4). Captured CCV steelhead will experience stress from handling and release and the risk of mortality and morbidity for those fish captured in the trammel net will increase as the water temperatures increase. Juveniles will likely be more stressed than adults due to their size. Adult CCV steelhead will not likely be entangled for more than a few minutes due to the constant attendance of the boat and crew watching for movement in the float line, which signifies that a fish has become entangled. All ESA-listed fish are to be released as quickly as possible if they are in "good shape." If any of these captured fish show signs of distress or are injured they will be resuscitated and placed in net pens for recovery before being returned to the river. This form of post-capture resuscitation has been shown to dramatically improve post-capture survival in salmonids (Farrell *et al*. 2001).

Approximately 80% percent of the annual juvenile CCV steelhead smolt population sampled in the Delta fish monitoring programs are caught from March through May (USFWS 2016). This includes hatchery as well as natural production. Movement of these CCV steelhead smolts through the Delta may be associated increases of tributary flows, but are much more variable than for Chinook salmon. Typically, CCV steelhead smolts average 250 mm FL (range 210-300 mm) in the Delta (CDWR 2013, 2014, 2015, 2016). At this size they could be entangled in the 2.5 inch square inner mesh of the trammel nets and may not have enough force to cause the buoys to bob. Therefore, they may experience longer times (up to 2 hours) in the nets before being detected, which increases the chance of mortality. However, based on the location of the trammel nets away from the main migratory pathway (main channel) only a small number of CCV steelhead smolts are likely to encounter the trammel nets.

In addition, CCV steelhead smolts released from the Fish Salvage Facilities are likely to encounter the trammel nets and be captured. Most CCV steelhead smolts are salvaged in March and April, with salvage tapering off in May. Based on annual fish salvage data from 2013–2016, October through July, approximately 837 steelhead (hatchery and wild) on average are salvaged per season (CDWR 2013, 2014, 2015, 2016). Since the trammel nets will only be deployed at one release site at a time (likely the CVP release sites first) roughly half of the total (837/2) or 418 salvaged steelhead smolts could be exposed to the trammel net. However, not all of these would encounter the nets during the study period. Based on a total net deployment time of 32 hours (32 hrs/2,160 hrs possible in the 3-month period), this represents 1.48 percent of the time being salvaged. In a worst case scenario, if all 418 salvaged steelhead from the CVP were released during the 32-hour sampling period (*i.e*., 0.0148 x 418 smolts), approximately 6 juvenile CCV steelhead would be exposed to the trammel nets at the release sites. This represents 0.0071 percent (*i.e.,* 6/837) of the average CCV steelhead salvaged (both hatchery and wild) per year in the last 4 years, and 0.00000110 percent (6/516,067) of the average of the total wild CCV steelhead juvenile population from 1998–2000 (Nobriga and Cadrett 2003).

In summary, a small number of adult and juvenile CCV steelhead may be captured or harmed as a result of deploying the trammel nets. These effects are expected to impact only a limited number of juveniles (<6) per year based on the salvage data from 2013–2016. 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 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 trammel nets and hydrophones during their deployment, operation, and retrieval. Likewise, adult green sturgeon are migrating through the Delta from March to May in the Sacramento River (Table 5). Currently, there is not a reliable measure of juvenile green sturgeon population abundance in the Delta, nor is there a reliable estimate of the relative fraction of the population utilizing the action area during implementation of the Project. Therefore, juvenile green sturgeon presence is assumed to occur during these periods without knowing the actual proportion of the population this comprises. Likewise, an unknown number of adult green sturgeon are likely to be migrating upstream during deployment of the trammel nets in the action area.

As discussed above for Chinook salmon, the operation of the hydrophones and DIDSON cameras is 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 sturgeons 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 (130–140 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.

Both adult and juvenile green sturgeon may be exposed to the trammel net. The nets will be checked every 2 hours of soak time, or when movement of buoys indicate fish are being caught, whichever comes first, in accordance with the sampling protocols to reduce or eliminate mortality or morbidity to fish entangled in the net. During March, April, and May when water temperatures in the action area can approach 21ºC (Figure 6), the water temperatures are not expected to be high enough to cause mortality during capture and handling, based on rearing preferences and behavior (Klimley *et al*. 2015). If left in the nets, green sturgeon can be particularly vulnerable to entanglement due to their physical shape (*e.g.*, sharp scutes and long rostrums) which catch in the mesh of the nets regardless of mesh size. Also, sturgeon behaviorally like to roll when they encounter nets, which is likely to increase their tendency to become entangled compared to other fish, and make it harder to remove them.

However, adult green sturgeon are not expected to be entangled for more than a few minutes due to the constant attendance of the boat and crew watching for movement in the float line and frequent net checks (every 2 hours). Green sturgeon are expected to be released as quickly as possible if they are in “good shape.” If any of these captured fish show signs of distress or are injured they will be placed in floating net pens near the release sites until they exhibit signs of recovery. Individuals that exhibit stress will be resuscitated following standard protocols before release. When these conditions are satisfied, they will be returned to the river near the study site. Post-capture resuscitation has been shown to dramatically improve survival in salmonids (Farrell *et al*. 2001), and is likely to benefit sturgeon as well. Constant attendance of the trammel net, rapid response to fish entanglement, and the availability of holding pens for resuscitation should minimize the risks of injury or mortality to captured adult and juvenile green sturgeon.

Depredation of sturgeon caught in nets and predation of released sturgeon by seals is known to occur in San Pablo Bay during gill-net sampling conducted by CDFW. The risk of predation by marine mammals, such as seals, is reduced or eliminated by patrolling the area before and removing the nets if a marine mammal is observed in the area.

In summary, some adult and juvenile green sturgeon may be captured or harmed as a result of deploying the trammel nets. 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 Project is expected to impact only a small number (1–3) of fish per year in 2017, 2018, and 2019. If the action were to result in the mortality of one adult green sturgeon, it would represent 0.0009 percent (1/1,008) of the population. The loss of an individual adult or juvenile is not expected to rise to the level where it will appreciably reduce the population's likelihood of survival and recovery.

2.7.7 Effects of the Project on Designated Critical Habitats

The proposed Project will have minimal effects on the designated critical habitats for winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon (see section 2.5.2). Within the action area, the relevant PBFs of the designated critical habitat for listed salmonids are migratory corridors and rearing habitat, and for green sturgeon, the six PBFs include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. No riparian habitat will be impacted. The Project is unlikely to demonstrably affect any PBFs for listed species. The Project will have minimal, short-term effects on the functioning of the critical habitat as a migratory corridor during the deployment of the trammel nets, which may impede migration in the waterways of the Sacramento and San Joaquin rivers. The nets will be deployed for short periods of time near-shore, and will not block the entire waterway, thus allowing the passage of fish in areas not occupied by the net. Captured fish will be delayed, but allowed to continue on their normal migration as soon as released. Delays in migratory movements due to capture, handling, and holding in net pens is not expected to exceed 8 hours (length of a sample day) during March, April, and May, when water temperatures are expected to be below 25^{o}C.

The placement of the anchors is not likely to substantially alter or degrade the function or value of the impacted substrate. The bottom substrate will return to an undisturbed condition within minutes of removal of the anchors. The anchors are small, approximately one foot square in area. A total of 8 anchors for the trammel nets and 20-40 anchors for the hydrophones will be deployed. The total area impacted by the anchors will be approximately 28–48 ft^2 (8+20–30 anchors * 1 ft^2/ anchor = 28–48 ft^2). The cumulative footprint of the small anchors will be in place for 2-3 weeks for the trammel nets and 2-3 months for the hydro-acoustic array during each season (*i.e.*, 2017, 2018, and 2019). There will be temporary negative effects to the benthic substrate, but it will have negligible effects on the functioning of the designated critical habitat and will be transitory due to the temporary nature of the deployment of the acoustic equipment over the 3 years of the Project, with a 9-month gap between deployments. The level of impact associated with the anchors for the hydrophones and trammel nets will not result in any permanent negative effects or loss of designated critical habitat in the action area.

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. NMFS also determined that the Project is not likely to adversely affect the designated critical habitats of the above listed species.

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

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 injury and mortality. The deployment and operations of trammel nets during the Project field seasons from April through May in 2017, and March through May in 2018 and 2019 is expected to result in (1) increased vulnerability to predation during the operations of the trammel nets; and (2) the impedance of free migratory movements of salvaged fish from the CVP/SWP fish Facilities and wild fish within the Sacramento and San Joaquin rivers.

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

- All ESA-listed fish that are entangled or captured in the trammel nets will be considered as part of the incidental take for the Project.
- Fish that are captured in the trammel nets and released either immediately or after resuscitation will be considered non-lethal take. Fish that are found dead in the nets, alive but with obvious injuries of a serious nature in the nets (*i.e.*, deep lacerations, damaged gills, profuse bleeding, *etc.*), or die during resuscitation attempts will be considered as lethal take. Total take, which includes both non-lethal and lethal take, are provided in Table 9.

Table 9: Summary of incidental take exempted for the proposed Project per study season through capture, handling, and releasing fish from trammel net monitoring.

ESA-listed species	Lifestage	Lethal	Non-lethal	Total
Winter-run	Adult[1]	1	2	3
	Juvenile[2]	4	10	14
CV Spring-run	Adult[1]	1	2	3
	Juvenile[2]	2	28	30
CCV steelhead	Adult[1]	1	4	5
	Juvenile[3]	2	6	8
sDPS green sturgeon	Adult[4]	1	2	3
	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] includes clipped (hatchery) and unclipped
[4] 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 or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize take of winter-run, CV spring-run, CCV steelhead, and sDPS green sturgeon resulting from implementation of the proposed action.

1. Reclamation shall increase the frequency of the net checks to once every hour when water temperatures exceed 20ºC, or when listed species are detected in the net, whichever comes first, to reduce stress and increase the likelihood of survival.

2. Reclamation shall monitor weather conditions, tidal conditions, and real-time fish salvage data during the deployment of the trammel nets to avoid sampling during adverse conditions or when large numbers of ESA-listed species may be present in the fish salvage.

3. Reclamation shall keep records of water temperature, DO level/percent saturation, net soak time, the number and species of fish captured, the number of mortalities, and number resuscitated.

4. 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). Reclamation or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this 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 increase the frequency of the net checks to once every hour when water temperatures exceed 20ºC, or when listed species are detected in the net, whichever comes first, to reduce stress and increase the likelihood of survival.**

    a) Hourly net checks shall extend to the end of the sampling day.

    b) Supplemental aeration shall be supplied, if necessary, to help resuscitate fish.

    c) Trammel nets shall be continually monitored. When nets are pulled to remove "larger fish" that disturb the float line, all observed fish shall be removed from the section of net lifted.

    d) Data shall be collected each time the nets are pulled, which shall include: numbers of fish captured by species, including number of listed species, body length (fork length), physical condition, number of mortalities (both immediate and fish dying during resuscitation), and for juvenile Chinook salmon, run classification based on the length-at-date classification (Delta model), as well as the physical data (*e.g.*, water temperature, oxygen concentrations and saturation, soak times for nets).

2. **Reclamation shall monitor weather conditions, tidal conditions, and real-time fish salvage data during the deployment of the trammel nets to avoid sampling during adverse conditions or when large numbers of ESA-listed species may be present in the salvage.**

   a) Reclamation shall monitor the forecasted tides on the Sacramento River and San Joaquin River so that trammel nets can be deployed before and after slack tides to reduce the likelihood of capturing migrating salmonids. Reclamation shall also monitor the predicted wind speeds to avoid fishing in adverse conditions. Reclamation shall monitor the daily salvage of ESA-listed species in real-time before making a release of tagged fish [either by contacting the Fish Facility Operators (Reclamation), or CDFW] to avoid releases of unusually high salvage (> 20 ESA-listed species/day). Daily fish salvage data can be monitored at: http://www.dfg.ca.gov/delta/apps/salvage/.

3. **Reclamation shall keep records of water temperature, DO level/percent saturation, net soak time, the number and species of fish captured, the number of mortalities, and number resuscitated.**

   a) Reclamation shall provide a weekly summary of the collected data to NMFS staff via email (bruce.oppenheim@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. **Reclamation shall monitor and report incidental take to NMFS.**

   a) Any Chinook salmon, steelhead or green sturgeon found dead or injured within 0.25 mile upstream or downstream of fishing gear deployment 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 held for pick up by NMFS personnel, or 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 June 30 of each study 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 by trammel net,
   iii. the number of listed species mortalities by species and run,
   iv. the number of listed species requiring resuscitation and their final disposition,
   v. a record of all marine mammals encounters or observations in the action area.

f) **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 June 30 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).

1. 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.

2. Reclamation should continue to work cooperatively with NMFS, CDWR, 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 Study*.

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.

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 the 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 opinion 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.

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