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

Refer to NMFS No: WCRO-2019-01933

September 24, 2019

Ramon Aberasturi
Regulatory Project Manager
California Delta Section
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Re: Endangered Species Act Section 7(a)(2) Biological Opinion for the Rio Vista Boat Launch Replacement Project (SPK-2016-00061)

Dear Mr. Aberasturi:

Thank you for your letter received on July 12, 2019, 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 Rio Vista Boat Launch Replacement Project.

Based on the best available scientific and commercial information, the biological opinion concludes that the Rio Vista Boat Launch Replacement Project is not likely to jeopardize the continued existence of the Federally listed endangered Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*), threatened Central Valley (CV) spring-run Chinook salmon evolutionarily significant unit (ESU) (*O. tshawytscha*), threatened California Central Valley (CCV) steelhead distinct population segment (DPS, *O. mykiss*), or the threatened southern DPS (sDPS) of North American green sturgeon (*Acipenser medirostris*), and is not likely to adversely affect their designated critical habitats. For the above species, NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take of listed species associated with the project.

Please contact Kristin Begun in NMFS' West Coast Region, California Central Valley Office via email at kristin.begun@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Maria Rea
Assistant Regional Administrator
California Central Valley Office

Enclosure

cc: To the file 151422-WCR2019-SA00536
Ramon Aberasturi (ramon.aberasturi@usace.army.mil), Regulatory Project Manager

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

Rio Vista Boat Launch Replacement Project

National Marine Fisheries Service Tracking Number: WCRO-2019-01933

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

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

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

Issued By:

Maria Rea
Assistant Regional Administrator

Date: September 24, 2019

LIST OF ACRONYMS

BA	biological assessment
BMP	best management practice
°C	degrees Celsius
CCV	California Central Valley
CDEC	California Data Exchange Center
CDFW/CDFG	California Department of Fish and Wildlife
cfs	cubic feet per second
Corps	United States Army Corps of Engineers
CRs	Conservation Recommendations
CVP	Central Valley Project
dB	decibels
Delta	Sacramento-San Joaquin River Delta
DOC	dissolved organic carbon
DPS	distinct population segment
DQA	Data Quality Act
EFH	essential fish habitat
EPA	United Stated Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
°F	degrees Fahrenheit
FHWG	Fisheries Hydroacoustic Working Group
FWCA	Fish and Wildlife Coordination Act
HAPCs	Habitat Areas of Particular Concern
ITS	incidental take statement
LID	low impact development
mg/L	milligram per liter
MS4	Phase II MS4 General Permit
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSD	Mossdale Bridge station
NPDES	National Pollutant Discharge Elimination System
NMFS	National Marine Fisheries Service
NTU	nephelometric turbidity units
OHWM	ordinary high water mark
Opinion	biological opinion
PAHs	polycyclic aromatic hydrocarbons
PBFs	physical or biological features
RBDD	Red Bluff Diversion Dam
RMS	root-mean-square
RPMs	reasonable and prudent measures
sDPS	Southern distinct population segment
SFS	Stockton Fire Station precipitation station
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program

LIST OF ACRONYMS CONTINUED

SOC	Stockton Airport precipitation station
SRA	shaded riverine aquatic
SWE	snow water equivalent
SWRCB	State Water Resources Control Board
THMFP	total trihalomethane formation potential
TMDL	Total Maximum Daily Load
TOC	total organic carbon
UC Davis	University of California at Davis
USFWS	United States Fish and Wildlife Service
VSP	viable salmonid population
WOUS	Waters of the United States
YOY	young-of-the-year
µg/L	microgram per liter

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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

NOAA's 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). A complete record of this consultation is on file at the NMFS California Central Valley Office.

1.2 Consultation History

- On June 28, 2017, the Corps contacted Doug Hampton (NMFS) by phone to discuss the Project and potential effects.
- On July 12, 2019, NMFS received a request for formal consultation from the Corps for the Rio Vista Boat Launch Replacement Project.
- Other than minor clarification questions, the information received on July 12, 2019, were sufficient. NMFS initiated consultation on this date.

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).

Project Description

The U.S. Army Corps of Engineers (Corps) proposes to issue a section 10 of the Rivers and Harbors Act permit to the City of Rio Vista to authorize the replacement of the existing City of Rio Vista boat launch on the Sacramento River, located at 1 Main Street, Rio Vista, in Solano County, California (Figure 1). The existing boat launch is deteriorated from age. The Rio Vista Boat Launch Ramp Replacement Project (Project) consists of replacing the existing concrete boat ramp, floating boat dock, retaining walls, and repaving the parking area. Equipment staging areas will be located in the paved areas near the boat launch ramp.

Figure 1. Project area location on the Sacramento River just south of the Rio Vista Bridge.

Riprap removal and cofferdam installation

In order to install sheet piles for a temporary cofferdam, some of the existing riprap must be removed. Since there is limited access from land, riprap may be removed with a barge-mounted excavator from the Sacramento River. To create a temporary cofferdam, 52-foot metal sheet piles will be installed approximately 34 feet deep into the substrate using a vibratory hammer. Sheet piles will be installed from north to south (upstream to downstream) to minimize the risk of fish entering the area during work activity. The sheet pile course is proposed to have a minor radius that would serve to help create a water tight seal. Sheet pile installation will be conducted during low tide to minimize impacts of noise and turbidity. Sheet pile installation is estimated to take 30 minutes per pile, for an estimated 20 hours of work, to occur over 2.5 days. The cofferdam will be approximately 100 feet long (30 meters). The cofferdam will temporarily block off approximately 3,800 square feet (0.09 acres) of water from the river. Once the cofferdam is installed, the area behind the cofferdam will be dewatered to dry the work area for the launch ramp and boat dock pile driving work to occur.

Dewatering and fish relocation

Once the cofferdam is constructed, the wetted area behind the cofferdam will be dewatered in accordance with a NMFS-approved dewatering plan. Qualified biologists will be onsite and prepared to safely handle and relocate listed fish species present during dewatering. If onsite

constraints exist which inhibit collecting fish with nets, then fish may be collected using electrofishing equipment. Pumps will be screened to minimize entrainment of fish. The pumps will run continuously to eliminate water. Pumped water will be treated to reduce suspended sediment by implementing Best Management Practices (BMP's) such as sediment bags or a baffled settlement tank. When the site has been dewatered, demolition and other construction activities will begin.

Demolition of boat ramp

The existing concrete boat ramp, retaining walls, abutment, apron, and dock with 6 steel piles will be demolished and removed. Equipment needed for this work will likely include an excavator, a dump truck, and a loader. Demolition material will be removed off site and disposed of. The area will then be graded and compacted with vibratory rollers, hand-held plate compactors, and a box grader.

Installation of concrete guide piles

The six dock piles that secured the floating dock (Figure 2) will be replaced with two 12-inch square, re-stressed reinforced concrete guide piles. The two guide piles will be installed in the dry, dewatered area. The guide piles are 90 feet in length and will be installed approximately 70 feet below the ground with an impact hammer with an estimated blow count of 320 strikes per pile. The existing 534 square foot (89 feet by 6 feet) floating dock will be replaced with a slightly larger 640 square foot (80 feet by 8 feet) floating dock. The new floating dock will be lowered over the two installed concrete guide piles once the ramp is poured and set.

Figure 2. Existing floating dock to be replaced and current condition of the concrete boat ramp (Photo from Corps Biological Assessment).

Concrete ramp

Forms with rebar will be installed and concrete ramp and retaining walls poured from a cement truck on land to create the new boat launch ramp. Concrete work will be at least 10 feet from the cofferdam. Concrete work for the walkway, apron, and abutment will be done at the same time as the ramp. Once the work site is cleaned up and concrete is cured, the cofferdam will be removed.

Sheet pile removal

Sheet piles for the temporary cofferdam will be removed from south to north (downstream to upstream) to minimize the possibility of fish entering the cofferdam as it is removed. The sheet piles will be removed with a vibratory pile driver from a barge. BMPs will be in place during removal to minimize impacts of disturbed substrate. A semi-circle floating boom with a weighted silt curtain will be installed adjacent and downstream of the piles being removed to allow sediment to settle. Sheet pile removal is estimated to take 30 minutes per pile, for an estimated 20 hours of work, to occur over 2.5 days.

Above the ramp, the parking area will be repaired or repaved with an asphalt concrete (AC) layer. After AC is in place, a vegetated swale will be constructed, as well as the installation of site lighting, project credit sign, and striping.

Construction work schedule

The Project is scheduled to occur between August 1 and November 30, 2020. The construction period is expected to have a duration of approximately 120 days.

Avoidance and Minimization Measures

- All exposed areas of disturbed soil would be watered twice per day to minimize fugitive dust emissions.
- All haul trucks transporting soil, sand, or other loose material off-site would be covered or maintain at least two feet of freeboard space. Any haul trucks traveling along freeways or major roadways would be covered.
- All visible mud or dirt track-out onto adjacent public roads would be removed using wet power-vacuum street sweepers at least once per day. Dry power sweeping would not be used.
- All construction equipment would be maintained and properly tuned in accordance with manufacturer's specifications.
- Stabilization of soil stockpiles, watering for dust control, establishment of perimeter silt fences and/or placement of fiber rolls would be used to control disturbed soil.
- Use of silt fences, stabilized construction entrances, and storm-drain inlet protection would be installed to prevent soil and other construction-related materials from leaving the Project area.
- Project-disturbed areas would be revegetated.

- The applicant, the City of Rio Vista, would install, implement, and maintain BMPs consistent with the California Storm Water Quality Association (2015) Best Management Practice Handbook or equivalent to minimize the discharge of pollutants, consistent with the requirements of the construction site stormwater and hazardous materials control requirements of the County of Sacramento, in compliance with Central Valley Regional Water Quality Control Board Order No. R5-2015-0023, National Pollutant Discharge Elimination System No. CAS082597.
- BMPs will be regularly monitored for effectiveness using appropriate methods (visual observation, sampling) at appropriate intervals (e.g., daily or weekly) and corrected immediately if determined to not be effective.
- A spill prevention and emergency response plan to handle potential spills of fuel or other pollutants.
- Drip pans will be placed under equipment and daily checks of vehicle condition.
- Trash and any other construction-related waste will be disposed of properly.

Interrelated and Interdependent Actions

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

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

The Corps determined the Project is not likely to adversely affect critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon. NMFS also determined that CV spring-run Chinook salmon and winter-run Chinook salmon are not likely to be adversely affected by the Project. Our discussion is documented in the "'Not Likely to Adversely Affect' Determinations" section (2.12).

2.1 Analytical Approach

This Opinion includes a jeopardy analysis that 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.

We use the following approach to determine whether a Project is likely to jeopardize the listed species:

- Identify the rangewide status of the species expected to be adversely affected by the Project.
- Describe the environmental baseline in the action area.
- Analyze the effects of the Project on the species 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 (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the Project poses to the species.
- Reach a conclusion about whether species are jeopardized.
- If necessary, suggest a RPA to the Project.

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 Project. 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. See Table 1 for species information.

Table 1. Description of species, current ESA listing classification, and summary of species.

Species	Listing Classification and Federal Register Notice	Status Summary
Sacramento River winter-run Chinook salmon ESU	Endangered, 70 FR 37160; June 28, 2005	According to the NMFS 5-year species status review (NMFS 2016c), the status of the winter-run Chinook salmon ESU, the extinction risk has increased from moderate risk to high risk of extinction since the 2007 and 2010 assessments. Based on the Lindley *et al.* (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners from 2016 through 2018. Several listing factors have contributed to the recent decline, including drought, poor ocean conditions, and hatchery influence. Thus, large-scale fish passage and habitat restoration actions are necessary for improving the winter-run Chinook salmon ESU viability.
Central Valley spring-run Chinook salmon ESU	Threatened, 70 FR 37160; June 28, 2005	According to the NMFS 5-year species status review (NMFS 2016b), the status of the CV spring-run Chinook salmon ESU, until 2015, has improved since the 2010 5-year species status review. The improved status is due to extensive restoration, and increases in spatial structure with historically extirpated populations (Battle and Clear creeks) trending in the positive direction. Recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2016 drought, uncertain juvenile survival during the drought are likely increasing the ESU's extinction risk. Monitoring data showed sharp declines in adult returns from 2014 through 2018 (CDFW 2018).
California Central Valley steelhead DPS	Threatened, 71 FR 834; January 5, 2006	According to the NMFS 5-year species status review (NMFS 2016a), the status of CCV steelhead appears to have remained unchanged since the 2011 status review that concluded that the DPS was in danger of extinction. Most natural-origin CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity

Species	Listing Classification and Federal Register Notice	Status Summary
		of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to natural-origin fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.
Southern distinct population segment of North American green sturgeon	Threatened, 71 FR 17757; April 7, 2006	According to the NMFS 5-year species status review (NMFS 2015) and the 2018 final recovery plan (NMFS 2018b), some threats to the species have recently been eliminated, such as take from commercial fisheries and removal of some passage barriers. Also, several habitat restoration actions have occurred in the Sacramento River Basin, and spawning was documented on the Feather River. However, the species viability continues to face a moderate risk of extinction because many threats have not been addressed, and the majority of spawning occurs in a single reach of the main stem Sacramento River. Current threats include poaching and habitat degradation. A recent method has been developed to estimate the annual spawning run and population size in the upper Sacramento River so species can be evaluated relative to recovery criteria (Mora *et al.* 2017).

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).

For the purpose of this consultation, the action area includes the Rio Vista boat launch project footprint, including staging areas and the surrounding areas that would be subjected to temporary construction-related noise, vibration, and turbidity. Turbidity is expected to be minimal, since pile driving work will occur at low tide and for a short duration (2.5 days for cofferdam installation and the same for cofferdam removal). The extent of the action area includes hydroacoustic effects to fish behavior, a distance of 100 meters (330 feet) from the pile driving activity.

The action area encompasses waterways where federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*, winter-run Chinook salmon), threatened Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*, CV spring-run Chinook salmon), threatened California Central Valley (CCV) steelhead (*O. mykiss*, CCV steelhead), and threatened Southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*, sDPS green sturgeon) may be present, and includes waters that have been designated as critical habitat for the above mentioned species. Adult winter-run Chinook salmon have the greatest potential to occur in the action area primarily from November to June (Hallock and Fisher 1985) and juveniles from November to April, based on

the timing of adult and juvenile migrations in and through the waterways of the Sacramento-San Joaquin Delta (NMFS 2016a). Adult CV spring-run Chinook salmon are likely to be present in the action primarily from January to June (Lindley *et al.* 2004) and juveniles from December to May (NMFS 2016a). Adult CCV steelhead have the greatest potential to be present in the Sacramento-San Joaquin Delta from August to May (Hallock *et al.* 1961, Moyle 2002), and juvenile CCV steelhead are likely to be present primarily from January to June (NMFS 2016a). Adult, sub-adult, and juvenile sDPS green sturgeon are presumed to be present year-round within the action area.

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).

2.4.1 *Water Development, Conveyance, and Flood Control*

The Delta has undergone many changes from its historical condition. The diversion and storage of natural flows by dams and diversion structures on Central Valley watersheds has depleted stream flows in the tributaries feeding the Delta and altered the natural cycles by which juvenile and adult salmonids and sDPS green sturgeon base their migrations. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and large woody debris. More uniform flows year round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation (Mount 1995, Herbold *et al.* 2018).

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of armored levees to increase channel flood capacity elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and freshwater riverine and estuarine habitat. Many of these levees use angular rock (riprap) to armor the bank from erosive forces. These changes affect the quantity and quality of nearshore habitat for juvenile salmonids (USFWS 2000). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators.

2.4.2 *Physical Disturbance from Dredging and Boating*

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has also significantly and detrimentally altered the natural hydrology and

function of the river systems in the Central Valley. This has led to declines in the natural meandering of river channels and the formation of pool and bar segments.

Currently, the Sacramento River experiences heavy barge and recreational vessel traffic, creating hazards to listed fish species through both physical and acoustic disturbance. These impacts, including increased levels of noise and turbidity, may lead to direct mortality or may induce changes in behavior that impair feeding, rearing, migration, and/or predator avoidance. In a report on Delta boating needs through the year 2020, (California Department of Boating and Waterways 2003) stated an expected increase in boating activity in the Delta area.

2.4.3 *Water Quality*

Current land use in the Delta has seen a dramatic increase in urbanization, industrial activity, and agriculture. The water quality of the Delta has been negatively impacted over the last 150 years; increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids and sDPS green sturgeon. In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time.

Multiple studies have documented high levels of contaminants in the Delta such as polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), selenium, and mercury, among others (Stewart *et al.* 2004, Leatherbarrow *et al.* 2005, Brooks *et al.* 2012), suggesting that fish are exposed to them. Harmful algal blooms also occur in the Delta and, although toxic exposure of estuarine fish has been documented, the extent of their impacts to the aquatic food web is unknown (Lehman *et al.* 2010). More recently, concerns have been raised about ammonia levels in the Delta (Davis *et al.* 2018). Pesticides and herbicides are found in the water and bottom sediments throughout the Delta. Herbicide use for the treatment and elimination of invasive aquatic vegetation may have important consequences for water quality parameters including: amount of light that reaches the water column, temperature, salinity, turbidity, and food availability, which may also influence the migratory paths that sDPS green sturgeon and salmonids utilize in the Delta.

2.4.4 *Hydrology in the Delta*

Substantial changes have occurred in the hydrology of the Central Valley's watersheds over the past 150 years. Many of these changes are linked to the ongoing actions of the Central Valley Project (CVP) and State Water Project (SWP). Reservoir operations flatten the natural hydrograph, resulting in a lack of the variability in seasonal and inter-annual runoff (Herbold *et al.* 2018). Currently, average winter/spring flows are typically reduced compared to natural conditions, while summer/fall flows have been artificially increased by reservoir releases.

These changes in the hydrographs of the two main river systems in the Central Valley are also reflected in the inflow and outflow of water to the Delta. The operations of the dams and water transfer operations of the CVP and SWP have reduced the winter and spring flows into the Delta, while artificially maintaining elevated flows in the summer and late fall periods. The Delta has

become a stable freshwater body, which is more suitable for introduced and invasive exotic freshwater species of fish, plants, and invertebrates than for the native organisms that evolved in a fluctuating and "unstable" Delta environment. Additionally, operating the CVP and SWP and the resultant conditions that are created, reduce survival of juvenile salmonids outmigrating through the Delta. Prior to the protections established by the CVP and SWP operations Opinion (NMFS 2009a), mortality of winter-run Chinook salmon juveniles entering the interior of the Delta, was estimated to be approximately 66 percent, with a range of 35-90 percent mortality (Burau *et al.* 2007, Perry and Skalski 2008, Vogel 2008). Studies indicate overall mortality through the Delta for late fall-run Chinook salmon releases near Sacramento from 2006 through 2010 ranged from 46 to 83 percent (Perry *et al.* 2016).

2.4.5 *Predation*

Predation of juvenile salmonids and sDPS green sturgeon is thought to be a contributing factor to high mortality at this life stage (Hanson 2009, Vogel 2011, Michel *et al.* 2015). There have been significant alterations to aquatic habitat that are conducive to the success of non-native piscivorous fish, such as creating a largely freshwater system out of the naturally estuarine, variable salinity Delta, riverbank armoring, and reduction of habitat complexity (Vogel 2011). The altered habitat and modified flow regimes have benefitted non-native striped bass, catfish, largemouth bass, and smallmouth bass, and Vogel (2011) found that predation was likely the highest source of mortality to anadromous fish in the Delta.

2.4.6 *Global Climate Change*

The global surface temperature is approximately 1.1°C (0.61°F) warmer today than pre-industrial levels. 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 2°C (3.6°F) in the 21st century (IPCC 2018). 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). Increased ocean temperatures will result in increased ocean acidity, decreased oxygen levels, a shift in marine species to higher latitudes, and degradation to marine ecosystems (IPCC 2018). Using objectively analyzed data, Huang and Liu (2000) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters (1.6 to 3.3 feet) along the Pacific coast in the next century mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (e.g., estuarine, riverine, mud flats) in the Delta. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, which will directly impact salmonids and sDPS green sturgeon during their migration through the Delta (e.g., warmer temperatures, turbidity) and would also affect their spawning success upstream.

Droughts along the West Coast and in the interior Central Valley of California are already occurring and are likely to increase with climate change. This means decreased groundwater

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

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2°C (3.6°F) and 7°C (12.6°F) by the year 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, U.S. Bureau of Reclamation 2014) with a drier hydrology predominated by precipitation rather than snowfall. The Sierra Nevada snowpack 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.

For winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. CV spring-run Chinook salmon adults over-summer in freshwater streams before spawning in autumn in the tributaries to the Sacramento River (Thompson et al. 2011). Those tributaries without cold water refugia will be more susceptible to impacts of climate change. Although CCV steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be greater, since juvenile CCV steelhead 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 CCV steelhead, which range from 15°C to 19°C (59°F to 66°F) (Myrick and Cech 1998). The Anderson Cottonwood Irrigation District (ACID) Dam is considered the upriver extent of sDPS green sturgeon passage in the Sacramento River, and spawning occurs approximately 30 kilometers (18.6 miles) downriver of the ACID Dam where water temperature is higher than ACID during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID Dam may remain within tolerable levels for the embryonic and larval life stages of sDPS green sturgeon, but temperatures at spawning locations lower in the river may be more affected.

In summary, observed and predicted climate change effects are generally detrimental to the species (McClure 2011, Wade et al. 2013), so unless offset by improvements, the status of the species is likely to decline over time. While there is uncertainty associated with climate change projections, which increase over time, the direction of change is relatively certain (McClure et al. 2013).

2.4.7 *Status of ESA-listed Species in Action Area*

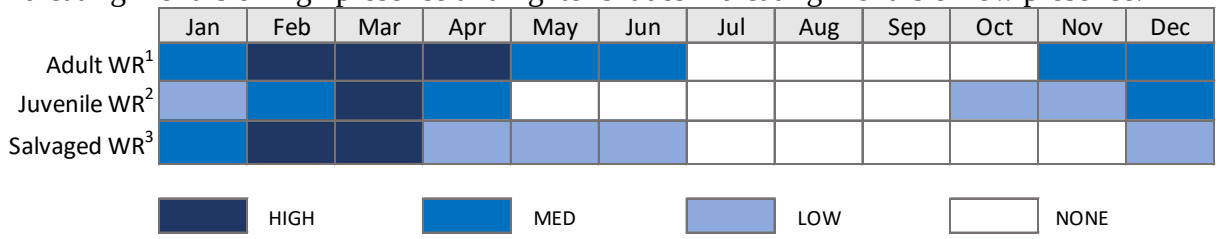
The action area, which encompasses part of the Sacramento River in Rio Vista, California, at and adjacent to the boat launch replacement site, functions as a migratory corridor for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. In addition, it also provides 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. sDPS green sturgeon use the area for rearing and migration year-round.

Adult winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will most likely pass through the action area on their way to their spawning grounds, unless they travel through Georgiana Slough, bypassing Rio Vista. No salmonids or sDPS green sturgeon spawning occurs in this part of the river, therefore no eggs or fry of these species are expected to occur in the action area.

2.4.7.1 Status of Sacramento River Winter-run Chinook Salmon in the Action Area

Adult winter-run Chinook salmon typically migrate through the Delta between November and June with the peak occurring in March on their way to their spawning grounds. They travel to Sacramento River Basin as late as July (Lindley *et al.* 2004), and then hold prior to spawning. Spawning occurs from August through October, with a peak in September (Moyle 2002). Generally, juveniles migrate downstream in the winter and spring. Juvenile winter-run Chinook salmon occur in the Delta primarily from November through early May, using length-at-date criteria from trawl and seine data in the Delta (USFWS 2016). Winter-run Chinook salmon may be present in the action area from November to June for adults, and November through April for juveniles (Table 2). In-river work is scheduled to occur from August 1 to November 30. Neither adult nor juvenile winter-run Chinook salmon are expected to be present during the majority of the construction season, but may be present in small numbers in October/November. However, cofferdam dewatering will occur earlier in the construction window, when winter-run Chinook salmon are least likely to be present.

Table 2. Temporal occurrence of winter-run Chinook salmon in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.



[1]Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).
[2]Juvenile presence in the Delta was determined using DJFMP data.
[3]Months in which salvage of wild juvenile winter-run Chinook salmon at the State and Federal fish collection facilities occurred; values in cells are salvage data reported by the facilities (NMFS 2016d).

2.4.7.2 Status of Central Valley Spring-run Chinook Salmon in the Action Area

Adult CV spring-run Chinook salmon migrate through the Delta from January to June, primarily during the months of February to April (CDFG 1998). As with winter-run Chinook salmon, adult CV spring-run Chinook salmon may migrate through and rear within the action area, but are not expected to be present in the action area during the Project. From the tributaries, juveniles migrate downstream soon after emergence as young-of-the-year, or they remain in the creeks until the following fall, which appears to be more typical (Moyle *et al.* 1995). According to trawl and seine data in the Delta, juvenile CV spring-run Chinook salmon are present in the Delta primarily from January to May, and are rarely observed during summer months (USFWS 2016). Adult CV spring-run Chinook salmon may be present from January to June (Table 3). Since in-river work will not be occurring during these months, neither adult nor juvenile CV spring-run Chinook salmon are expected to be present during Project construction.

Table 3. Temporal occurrence of spring-run Chinook salmon in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SR[1]												
Juvenile SR[2]												
Salvaged SR[3]												

HIGH MED LOW NONE

[1]Adults enter the Bay late January to early February (CDFG 1998) and enter the Sacramento River in March (Yoshiyama *et al.* 1998). Adults travel to tributaries as late as July (Lindley *et al.* 2004). Spawning occurs September to October (Moyle 2002).
[2]Juvenile presence in the Delta based on DJFMP data.
[3]Juvenile presence in the Delta based on salvage data (NMFS 2016d).

2.4.7.3 Status of California Central Valley Steelhead in the Action Area

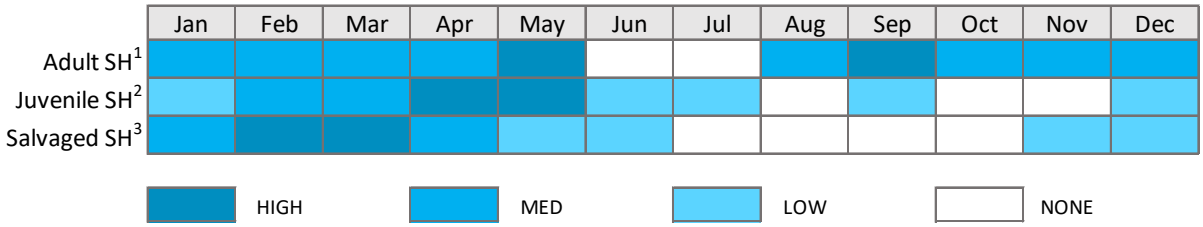
Adult CCV steelhead enter freshwater in August (Moyle 2002) and the peak migration of adults moving upriver occurs in in late September (Hallock *et al.* 1957). They hold until tributary flows are high enough to migrate upstream where they spawn from December to April (Hallock *et al.* 1961). A small percentage of CCV steelhead (typically females) migrate back downstream from the tributaries and reach the Sacramento River during March and April, and have a high presence in the Delta in May.

Juvenile CCV steelhead (smolts) may be present in the action area as early as September (CDFW 2016, USFWS 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, with peak migration through the Delta in March and April (Reynolds *et al.* 1993). CCV steelhead presence in CVP and SWP fish salvage facilities, which account for CCV steelhead from both the Sacramento and San Joaquin river basins, increases from November through January and peaks in February and March. By June, emigration essentially ends, with only a small number of fish being salvaged through the summer (Table 4). According to DJFMP data, juvenile CCV steelhead are primarily present in the Delta from February to June (Table 4). Hallock et al. (1961) also describes a similar timeframe for

juvenile outmigration from the upper Sacramento River and its tributaries during late December through April.

Since adult CCV steelhead may be present in the action area during their migration upstream, they have a higher chance of being present during the Project than Chinook salmon. Though unlikely, juvenile CCV steelhead may be present during the months of September and November, overlapping with the in-river construction period (August 1 to November 30).

Table 4. Temporal occurrence of steelhead in the Delta, with darker shades indicating months of high presence and lighter shades indicating months of low presence.

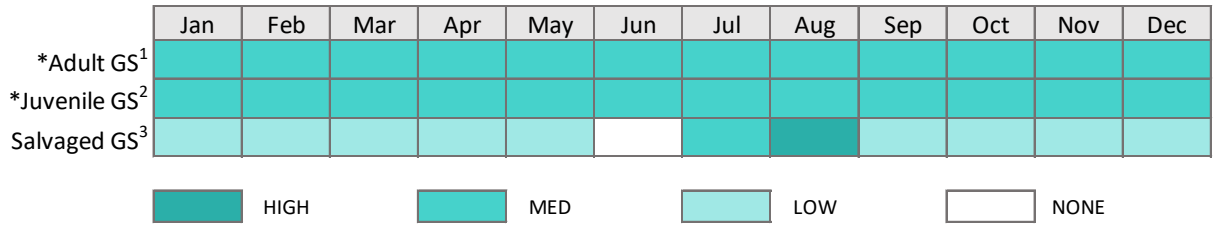


[1]Adult presence was determined using information in (Moyle 2002), (Hallock *et al.* 1961), and (CDFW 2007).
[2]Juvenile presence in the Delta was determined using DJFMP data.
[3]Months in which salvage of wild juvenile steelhead at the State and Federal fish collection facilities occurred; values in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

2.4.7.4 Status of Southern Distinct Population Segment of North American Green Sturgeon in the Action Area

For sDPS green sturgeon, the action area functions as migratory, holding, and rearing habitat for adults, sub-adults, and juveniles. Green sturgeon are presumed to be present year-round in the Delta (Table 5). Both non-spawning adult and sub-adult sDPS green sturgeon use the Delta and estuary for foraging during the summer. Green sturgeon spawning primarily occurs in cool sections of the upper mainstem Sacramento River (NMFS 2018b), therefore no eggs or larval sDPS green sturgeon are expected to occur in the action area. Adult and juvenile sDPS green sturgeon may be present during the Project since they occur in the Delta year-round, but due to their small population size, few are expected to be present during in-water work activities.

Table 5. Temporal occurrence of sDPS green sturgeon in the Delta, with darker shades indicating months of high presence and lighter shades indicating months of low presence.



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

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

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

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

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 Project and are later in time, but still are reasonably certain to occur.

2.5.1 *Effects of the Project to Listed Fish Species*

The effects of the Project are based on best available life history information and monitoring data on the four species for which their geographical ranges occur in the action area. In-water work is scheduled to occur from August 1 to November 30, 2020. Life stages of species that are expected to be present during the proposed in-water work window include juvenile and adult CCV steelhead, and juvenile, sub-adult, and adult sDPS green sturgeon. In this section of the Sacramento River where the Project will occur, there are no known spawning areas for salmonids or sDPS green sturgeon, so impacts or mortality to eggs are not expected to occur. The following analysis includes potential sources of adverse effects for the species resulting from the Project.

Increased Sedimentation and Turbidity

Increased sedimentation and turbidity may occur during cofferdam sheet pile installation within the active channel. A vibratory hammer will be used to install sheet piles from a barge temporarily anchored with spuds in the Sacramento River. This work will occur over 2.5 days. The removal of the temporary sheet piles will also occur over 2.5 days. These activities will disturb the substrate possibly resulting in increased turbidity and sedimentation. Pile driving of the two permanent 12-inch concrete dock piles will occur within the dry area behind the cofferdam, and therefore should not be a source of turbidity or sedimentation. Sources outside of the active channel include disturbance of soil during removal of some existing riprap that

conflicts with the cofferdam. Since staging areas will be over paved areas, vegetation removal will not be necessary.

Juvenile and adult CCV steelhead are known to use the action area as a migration corridor and for rearing during the proposed in-water work window (August 1 to November 30) and, therefore, may be present during construction activities. Increased sedimentation and turbidity could have direct and indirect adverse effects to adult fish through gill fouling, reduced foraging ability and reduced predator avoidance (Kemp *et al.* 2011). Juvenile salmonids are unlikely to avoid increased levels of turbidity below a level of 70 nephelometric turbidity units (NTU, Bash *et al.* 2001). As a result, they may be at greater risk to turbidity and sediment-related effects than adults. One effect of turbidity that has important implications for juvenile salmonids is that predator avoidance behavior has been shown to decrease at increased levels of turbidity (Gregory 1993). Growth and survival amidst increased sediment and turbidity levels have also been shown to decrease resulting from reduced prey detection and availability. Physical injury is also possible due to increased activity, aggression, and gill fouling (Suttle *et al.* 2004, Kemp *et al.* 2011). Less information is available on the abundance and distribution at various life stages of sDPS green sturgeon. However, based on the best available information on their life history, individuals at the juvenile, sub-adult, and adult life stages could be present in the action area. Large increases in turbidity as well as sedimentation events have the potential to cause acute injury by gill fouling in sDPS green sturgeon.

With the implementation of avoidance and minimization measures, potential direct or indirect adverse effects resulting from sedimentation and turbidity are minimal and are therefore not expected to negatively affect listed fish species.

Contaminants and Pollution-related Effects

The Project will involve heavy construction equipment and activities that could impair water quality if a spill were to occur. Potential sources of pollutants include petroleum products such as fuel, hydraulic fluid, and petroleum-based lubricants. BMPs will be in place, and avoidance and minimization measures will be implemented, minimizing the probability of pollutant incursion into the Sacramento River. However, unlike sedimentation and turbidity-related effects, potential pollution-related effects have the potential to be persistent in the action area and may affect multiple species and life stages if they were to occur.

Incursion of contaminants into the action area has the potential to directly or indirectly affect species present during or post-construction. Heavy equipment will be present in the action area and metals may be deposited through their use and operation (Paul and Meyer 2001). These materials have been shown to alter juvenile salmonid behavior through disruptions to various physiological mechanisms including sensory disruption, endocrine disruption, neurological dysfunction and metabolic disruption (Scott and Sloman 2004). Oil-based products used in combustion engines are known to contain PAHs, which have been known to bio-accumulate in other fish taxa such as Pleuronectiformes and have carcinogenic, mutagenic and cytotoxic effects (Johnson *et al.* 2002). The exact toxicological effects of PAHs in salmonids and sturgeon is not well understood, although studies have shown that increased exposure of salmonids to PAHs reduced immunosuppression, increasing their susceptibility to pathogens (Arkoosh *et al.* 1998).

Adult and juvenile winter-run Chinook salmon may be present in the action area as early as November, adult and juvenile CCV steelhead and sDPS green sturgeon may also be present in the action area during the in-water construction work window (August 1 to November 30). CV spring-run Chinook salmon are unlikely to be present in the action area during this time.

BMPs and avoidance and minimization measures will aid in minimizing or avoiding potential direct or indirect adverse effects to listed fish species. With these avoidance and minimization measures in place, potential direct or indirect adverse effects resulting from the incursion of contaminants into the Sacramento River are improbable and are therefore not expected to occur.

Dewatering and Fish Rescue Operations

In-water cofferdam installation is expected to take 2.5 days, and during this process the closure of the cofferdam may entrap juvenile fish. Cofferdam work is anticipated to occur at the beginning of the in-water work window in August, since this step must occur prior to boat launch ramp or dock work. The cofferdam installation process will likely startle most of the fish near the construction site and cause them to leave the immediate area of work. However, it is possible that some fish will be entrained before the cofferdam is sealed. In August, juvenile winter-run Chinook salmon are unlikely to be present in the action area. Juvenile CCV steelhead and juvenile sDPS green sturgeon may be present year round, and therefore, may be in the action area during cofferdam installation. CV spring-run Chinook salmon are not expected to be present during this time.

During the dewatering process, a qualified biologist will be onsite to oversee the activity and be prepared to relocate fish. In the event fish are observed within the cofferdammed area, they would be collected with nets and relocated to the main channel of the Sacramento River. If onsite physical constraints exist which make netting impractical, electrofishing equipment may be used to capture stranded fish. Electrofishing causes fish to be temporarily immobilized, or if electrical currents are too strong, can cause spinal injury, leading to mortality. Smaller fish are less susceptible to the effects of the electrical current than larger fish. Any fish that are immobilized due to electrofishing will typically recover after a few seconds to a few minutes (FFWCC). Biologists using electrofishing equipment would follow NMFS' electrofishing guidelines. ESA-listed species that may be present in the action area during dewatering may be susceptible to capture or electrofishing, and relocation. For fish that may be present, incidental injury or mortality may occur during this process as fish experience abrasion from handling, exposure to air, exposure to electrical current from electrofishing, close proximity to one another as they are relocated downstream, and potential predation upon release.

Hydroacoustic Noise Impacts due to Pile Driving

Hydroacoustic pressure impulses can affect behavior of fish and may result in physical injury such as tissue damage, hearing loss, or death (Popper and Hastings 2009). Any alteration in behavior or physical injury can increase the chance of predation due to disorientation, and the ability to feed or migrate. NMFS established criteria for hydroacoustic impacts on fish, and has identified a peak pressure of 206 dB, a cumulative Sound Exposure Level (SEL) of 187 dB for fish greater than 2 grams, and a cumulative SEL of 183 dB for fish less than 2 grams (NMFS

2009b). NMFS also uses a Root Mean Square (RMS) of 150 dB as a threshold for creating negative behavioral effects to exposed fish.

The City of Rio Vista proposes to install two 12-inch concrete guide dock piles in the dewatered area behind the cofferdam. The guide dock piles would be installed using a vibratory hammer. Since the vibratory hammer produces sound energy that is generally 10 to 20 decibels (dB) lower than impact pile driving (Caltrans 2015), sound pressure levels would be lower than those associated with the impact hammer to install the two guide piles. Attenuation of 5 dB was used to account for pile driving occurring in the dewatered (dry) area. According to Table VI-2 from the Technical Guidance for Assessment and Mitigation of Hydroacoustic Effects of Pile Driving on Fish (Caltrans 2015), the closest comparison is to 18-inch concrete piles (which are larger than the 12-inch piles to be used) which would produce sound levels of 180 dB_{Peak} sound pressure, 165 dB_{RMS}, and 155 dB_{SEL} (see Table 6). Using these values, the extent of hydroacoustic effects to fish behavior is a distance of approximately 100 meters (328 feet) (distance to behavioral threshold is greater for vibratory hammer than for pile driving the two piles in the dry).

Table 6. Values from NMFS Pile Driving Calculator for anticipated noise impacts.

Pile Type	Driver Type	Number of Strikes Per Pile	Strikes Per Day	Reference Distance (m)	Attenuation (dB)	Peak (dB)	SEL (dB)	RMS (dB)	Distance (m) to Threshold			
									Onset of Physical Injury			Behavior
									Peak dB	Cumulative SEL dB		RMS dB
										Fish >2 g	Fish < 2 g	
									206 dB	187 dB	183 dB	150 dB
12" square concrete (2)	impact hammer	320	640	10	5	180	165	155	0	25	47	22
steel sheet (40)	vibratory hammer											100

The NMFS pile driving calculator worksheet shows that peak sound pressure levels will be well below the threshold of 206 dB (180 dB). Cumulative SELs are anticipated to be elevated; 187 dB at a distance of up to 25 meters (82 feet). Pile driving work for the two guide dock piles will occur during daylight hours over one day. Listed salmonids are least likely to be present during the August 1 through October 31 portion of the in-water work window. During the November 1 to November 30 period, winter-run Chinook salmon, steelhead, and green sturgeon may be present. Due to the number of pile strikes in one day (640 strikes), the SEL threshold for fish greater than 2 grams will be exceeded, according to the NMFS pile driving calculator. However, fish are most likely to migrate through the action area at night. Also, the noise disturbance from the pile driving activity is likely to deter fish from the area. Since fish are not likely to stay in the action area for the duration of pile driving work, they are unlikely to be exposed to the cumulative noise impacts (SEL) from pile driving activities. Therefore, effects from noise to fish migrating through the action area will be minimal, and are not expected to negatively affect list fish species.

The single strike RMS pressure is estimated to be 155 dB. The distance to reach the 150 dB Effective Quiet level is 22 meters (72 feet) from the source. However, noise due to sheet pile installation for the cofferdam is expected to extend 100 meters (328 feet) from the source (See Table 6). Behavioral impacts to fish within this distance may include being startled and fish moving away from the affected area (Caltrans 2015). Since the river is 750 meters (2,460 feet) wide in this section, listed fish species present in the action area may avoid the action area (100 meters from the cofferdam into the channel) during their upstream or downstream migration and use another part of the river beyond noise impacts.

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 Project 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*

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

2.6.2 *Increased Urbanization*

Increased urbanization is expected to result in increased recreational activities in the Delta and the action area and its vicinity. 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 are poorly regulated, will lead to increased emissions of greenhouse gases. It is unlikely that NMFS will be involved in any review of these actions through an ESA section 7 consultation. Within the context of the brief period of time over which the Project is scheduled to be operated (four months), 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 as a result of implementing the Project. 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 (Section 2.2), to formulate the agency's biological opinion as to whether the Project is likely to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution.

2.7.1 *Summary of the Status of the Species and Environmental Baseline*

The Status of the Species 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 status reviews (NMFS 2015, 2016a, 2016b and 2016c) that the listings are still warranted, and that the current status of these fish has continued to decline since the previous status 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 Chinook salmon, CV spring-run Chinook salmon, 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 Chinook salmon, 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 Project*

The Project will occur from August 1 to November 30. The effects of installing and removing the cofferdam; and removing the old dock, 6 dock piles, and launch ramp and installing a new dock, 2 dock piles, and new launch ramp behind the cofferdam will be temporary and minimal.

The aspects of the Project that will result in adverse effects to CCV steelhead and sDPS green sturgeon include potential handling and relocation of fish, and potential use of an electrofisher during dewatering of the cofferdammed area. NMFS expects the potential for individuals to be harmed or injured, including the potential for mortalities and susceptibility to predation upon release, as a result of the fish relocation. However, these effects are expected to be minor in scope in relation to the species' respective populations, affecting a limited number of fish for each species.

2.7.3 *California Central Valley Steelhead*

Adult CCV steelhead are most likely to be migrating through the waters of the action area during August to May, based on their migration timing upstream and downstream after spawning. Juvenile CCV steelhead are primarily expected to begin entering the action area during December, when cool and wet weather is likely to promote downstream emigration. As a result, few juvenile CCV steelhead are expected to be exposed to the effects of the action, although juveniles are occasionally observed at monitoring locations during summer months. Although adult CCV steelhead may be present during the in-water work window, adults are unlikely to travel near shore and become entrapped in the cofferdam.

Sheet pile installation is not expected to adversely affect juvenile or adult CCV steelhead, since piles will be driven with a vibratory hammer, and any turbidity caused from the disturbance will be temporary, localized, and minimal.

Cofferdam dewatering will occur after the temporary cofferdam is constructed likely early in the August 1 to November 30 work window, to remove water from the work area in preparation for boat launch replacement. Any fish within the enclosed area (see Figure 3) would be entrapped and later rescued during the dewatering process. The area to be dewatered is approximately 0.09 acres, approximately 30 meter (98 feet) long by 10 meters (33 feet) wide, in a section of the Sacramento River that is 750 meters (2,460 feet) wide. Also, during construction activity, most fish are expected to avoid the area of disturbance during cofferdam installation. Since work is expected to occur over 2.5 days during daylight hours, it is possible that some fish may enter the launch ramp area and become entrapped behind the cofferdam, particularly at night when no construction activity is occurring. Cofferdam dewatering has the potential to harm, injure, or kill juvenile CCV steelhead. Adult fish are unlikely to become entrapped in the cofferdam during construction and are therefore unlikely to be affected by dewatering.

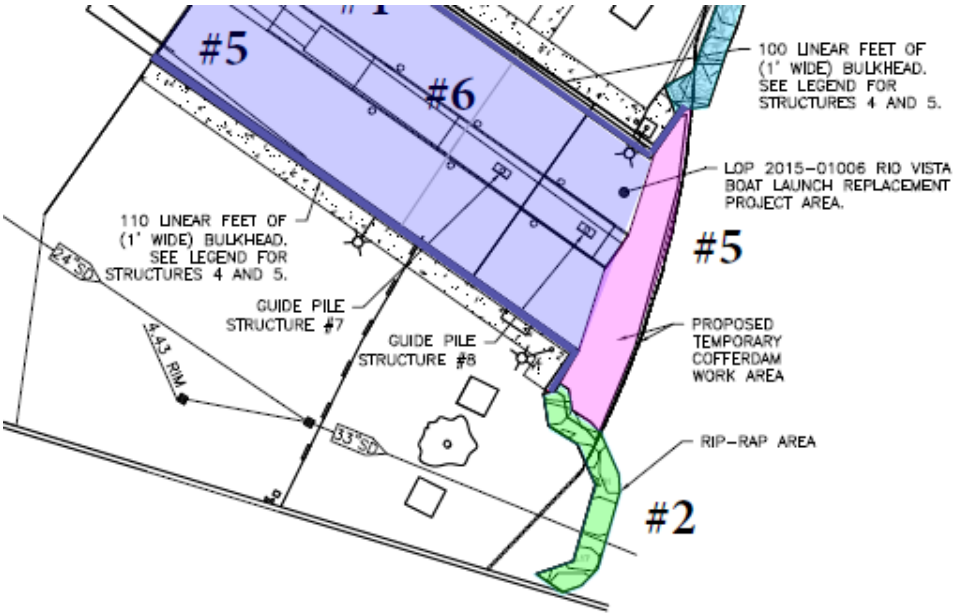


Figure 3. Section of river enclosed by the cofferdam to be dewatered shown in pink and purple shaded areas (Photo from Corps Biological Assessment enclosure 2).

According to normalized DJFMP data, 1.85 percent of juvenile CCV steelhead migrate through the Delta from August through November (USFWS 2000-2016). From 2000 to 2016, an average of 0.08 CCV steelhead (length-at-date) were collected at monitoring locations in August, 0.23 in September, 0.08 in October and 0 in November (sum of 0.4 fish).

The estimated time to install the cofferdam is 2.5 days (20 hours total) during daylight hours. Assuming work occurs three days in a row, and the cofferdam is not left partially complete over a weekend or holiday, the number of days that fish may enter the area is three, before the cofferdam is sealed. Juvenile fish are most likely to enter the launch ramp area at night when no construction activities are occurring. Three days during the four-month construction window (August through November) is 2.47 percent of the 4-month period [(3 days/(4/12*365))*100%]. If we conservatively assume that the cofferdammed area would entrap juveniles at the same rate as monitoring stations throughout the Delta, then 0.4 juvenile CCV steelhead may be subjected to the dewatering process. If the cofferdam will be partially open for 2.47 percent of the time, then approximately 0.01 fish (0.0247 x 0.4 fish) will be present in the action area during the period when juveniles may be entrapped. Approximately 1 juvenile CCV steelhead (rounding up from 0.01 fish) would be exposed to handling and relocation and potential exposure to electrofishing during the dewatering process. 0.01 fish does not represent a large portion of the population, considering 635 juvenile CCV steelhead were collected at DJFMP sites from 2000 to 2016 (USFWS 2000-2016) and the majority of fish migrating through the Delta are not collected at monitoring sites.

Juvenile CCV steelhead are not likely to be within the action area since they are more likely to be present in the main channel rather than near the shoreline. However, any juvenile CCV steelhead that do enter the cofferdammed area and do not exit prior to its closure, will be subject to the fish rescue operation during the dewatering process. This will entail being netted, handled, potentially subjected to electrofishing, placed in a container, and transported back to the main

channel of the Sacramento River. Prior to and during dewatering, qualified biologists, pre-approved by NMFS, will clear as many fish as possible with appropriately sized nets. If biologists are unable to net fish due to physical constraints such as uneven channel bottom, then some fish may be captured by electrofishing. Dewatering will be accomplished by pumping water from the work area after completion of the cofferdam. Pumps used to dewater will be screened and operated in accordance with NMFS screening specifications. Pumped water will be filtered through a filter bag, discharged to a settling tank and/or treated to ensure compliance with water quality requirements prior to discharge.

In summary, the harassment, injury, or death of one juvenile CCV steelhead by fish handling, relocation, temporary immobilization as a result of electrofishing, and potential predation upon release, is not expected to impact the population's likelihood of survival and recovery.

2.7.4 Southern DPS Green Sturgeon

Since juvenile sDPS green sturgeon are expected to be rearing in the waterways of the Delta on a year-round basis, they are expected to be in the vicinity of the cofferdam during installation. Currently, there is not a reliable measure of juvenile sDPS green sturgeon population abundance in the Delta, nor is there a reliable estimate of the relative fraction of the population utilizing the action area during implementation of the Project. Therefore, juvenile sDPS green sturgeon presence is assumed to occur year-round without knowing the monthly proportion of the population.

Adult sDPS green sturgeon are migrating upstream through the Delta to the Sacramento River from March to July (Moyle 2002) and emigrating downstream from November to December and from June to August (Heublein and J.T. Kelly 2009). Hence, there may be adult sDPS green sturgeon migrating upstream or downstream during Project activities. However, adult sDPS green sturgeon are not likely to become entrapped during cofferdam installation, particularly due to their large size and their preference for deeper water in the main channel away from the shallow shoreline.

As discussed above for juvenile salmonids, activities including sheet pile installation and removal are not expected to adversely affect either adult or juvenile sDPS green sturgeon in the action area. Any noise produced during pile driving within the dewatered area is not expected to produce sound exposures that would cause injury or death to exposed sDPS green sturgeon due to the short-term duration and magnitude. Thus, these activities are not expected to have any impact on sDPS green sturgeon that are moving within the range of the activities.

Juvenile sDPS green sturgeon are unlikely to enter the area within the cofferdam due to disturbance of the Project activities during the three days that cofferdam installation may occur, and although their numbers are unknown, they are presumed to be low. However, if any juveniles are in the vicinity and enter the partially complete cofferdam prior to closure, they may be negatively affected when exposed to handling and relocation during the dewatering process.

The DJFMP rarely catches juvenile sDPS green sturgeon at seine and trawl monitoring sites due to their tendency to remain at deeper depths. From 1976 to 2016, only 18 juvenile green sturgeon were reported (USFWS 2000-2016). A greater number of sDPS green sturgeon have been

observed in salvage in the south Delta. From 1981 to 2012, 7,200 juveniles were reported at the State and Federal export facilities, with a higher presence of juvenile sDPS green sturgeon during the spring and summer months in the south Delta where export facilities are located (CDFW 2016). Of the 18 juveniles that were collected at DJFMP monitoring sites throughout the Delta, 2 were observed during the in-water work window (1 in August and 1 in November). If we assume that 2 juveniles will be present in the action area, then 0.05 fish (0.0247 x 2 fish) may be exposed to the effects of the dewatering process. sDPS green sturgeon can be particularly vulnerable to electrofishing due to their physical size. If juvenile sDPS green sturgeon are encountered by the electric current, they would likely be immobilized or suffer more severe injuries than juvenile salmonids.

In summary, 1 juvenile sDPS green sturgeon (rounding up from 0.05 fish) may be harmed, injured, or killed as a result of dewatering. Recently, an annual run size has been estimated at 2,106 adults and 4,387 juveniles in the Sacramento River, with a total population size of 17,548 individuals (Mora *et al.* 2017). The Project is expected to impact only a small number of fish. If the Project were to result in the mortality of five juvenile sDPS green sturgeon, it would represent 0.02 percent (1/4,387*100%) of the estimated juvenile population and 0.006 percent (1/17,548*100%) of the total population. The loss of 1 juvenile is not expected to rise to the level where it will appreciably reduce the population's likelihood of survival and recovery.

2.8 Conclusion

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

2.9 Incidental Take Statement

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

2.9.1 *Amount or Extent of Take*

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

NMFS anticipates that the Project may result in the incidental take of individual juvenile CCV steelhead and sDPS green sturgeon. Incidental take associated with this action is expected to be in the form of harassment, injury, or mortality. Handling, relocating, and being exposed to electrofishing during the dewatering process occurring in August to November 2020 is expected to result in physical harassment, injury, or mortality as a result of the electrofishing or handling, and relocation of fish.

Table 7 provides a summary of incidental take associated with the Project.

Table 7. Summary of incidental take exempted for the Project through exposure of netting, handling, releasing fish, and potential electrofishing, during dewatering of the cofferdam.

ESA-listed species	Life Stage	Lethal[2]	Non-Lethal	Total
CCV steelhead[1]	Juvenile	0	1	1
sDPS green sturgeon	Juvenile	1	0	1

[1] Run determined by the length-at-date classification (Delta model).

[2] Includes fish that are found dead or alive but with obvious injuries of a serious nature (i.e., broken spine).

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 Project, is not likely to result in jeopardy to the listed species.

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).

1. The Corps shall minimize the duration of cofferdam installation.

2. The Corps shall ensure all electrofishing operators have proper training and experience.

3. The Corps shall monitor and prepare a report on the amount or extent of incidental take to NMFS.

2.9.4 *Terms and Conditions*

The terms and conditions described below are non-discretionary, and the Corps or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The Corps 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 Project would likely lapse.

1. The following term and condition implements reasonable and prudent measure 1: The Corps shall minimize the duration of cofferdam installation.

    a. Cofferdam installation shall occur within 3 consecutive days, so it is not left partially complete or inactive, in order to minimize the number of days/nights that fish may enter the area and become entrapped.

2. The following term and condition implements reasonable and prudent measure 2. The Corps shall ensure all electrofishing operators have proper training and experience.

    a. Electrofishing operators must have appropriate training and experience with electrofishing techniques. Training for field supervisors can be acquired from programs such as those offered from the U.S. Fish and Wildlife Service (USFWS) - National Conservation Training Center (Principles and Techniques of Electrofishing course) where participants are presented information concerning such topics as electric circuit and field theory, safety training, and fish injury awareness and minimization. A crew leader having at least 100 hours of electrofishing experience in the field using similar equipment must train the crew. The training must occur before an inexperienced crew begins any electrofishing and should be conducted in waters that do not contain ESA-listed fish.

3. The following term and condition implements reasonable and prudent measure 3: The Corps shall monitor and prepare a report on the amount or extent of incidental take to NMFS.

    a. Any winter-run or CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon injured or killed during the dewatering activity shall be reported immediately to NMFS via fax or phone within 24 hours of discovery to:

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

    b. Any dead specimen(s) shall be placed in a cooler with ice and sent to:

        NMFS, Southwest Fisheries Science Center
        Fisheries Ecology Division
        110 Shaffer Road,
        Santa Cruz, California 95060.

    c. The Corps shall make records/log books available to any personnel from NMFS' Office of Law Enforcement, or the California Department of Fish and Wildlife (CDFW) Wardens, upon request for review of compliance with the terms and conditions.

    d. On-site biologists shall carry a copy of the ITS at all times while in the field.

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 Project on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. The Corps should improve compliance and implementation of BMPs to reduce input of non-point source sediment into waterways where ESA-listed species may be present. Contaminants through run-off and agricultural practices on the prey base are considered a high threat to juvenile sDPS green sturgeon (NMFS 2018b) and also threaten water quality for salmonids. Preventing contaminants from entering waterways through use of proper BMPs will help preserve the value of critical habitat for threatened and endangered species.

2. The Corps should recommend to project applicants to post signs in the action area about stormwater pollution and runoff, advising citizens of the presence of listed fish species and to not discharge any chemicals, oils or other waste products near the stream. This is critical for protecting aquatic biota from exposure to harmful pollutants.

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

2.11 Reinitiation of Consultation

This concludes formal consultation for the Rio Vista Boat Launch Replacement Project (SPK-2016-00061).

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 (50 CFR 402.16).

2.12 "Not Likely to Adversely Affect" Determinations

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

NMFS has determined that while the Project may affect critical habitats for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon due to the placement of temporary barge anchors, temporary cofferdam installation, and replacement of the boat launch and dock, the Project is not likely to adversely affect critical habitats for the above listed species.

2.12.1 *Effects of the Project on Listed Fish Species and Designated Critical Habitats*

NLAA Determination on Listed Fish Species

For reasons described in section 2.5.1 (effects of the Project to listed fish species) for CCV steelhead, NMFS does not anticipate the Project will result in adverse effects to winter-run Chinook salmon and CV spring-run Chinook salmon from turbidity and sedimentation, contaminants, and hydroacoustic impacts. In addition, winter-run and CV spring-run Chinook salmon are not likely to be present in the action area during the proposed in-water work window, and will not be subjected to the fish rescue operation during the dewatering process, and therefore effects are discountable, as they are unlikely to occur.

NLAA Determination for Designated Critical Habitats

The Project will also have insignificant effects on the designated critical habitats for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Within the action area, the relevant PBFs of the designated critical habitat for listed salmonids are freshwater migratory corridors and rearing habitat, and for sDPS green sturgeon the relevant PBFs are food resources, water flow, water quality, migratory corridors, and water depth.

The minimal contact with the underlying channel substrate from the barge spuds during pile driving work is not expected to result in any negative changes to the substrate for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon designated critical habitats that might impact production of forage organisms or disturb habitat complexity or composition. Since sheet piles for the cofferdam will only be in place for one season primarily during the summer months, they will not cause impacts to critical habitat that would significantly disturb or alter PBFs for listed fish species.

Turbidity caused by the barge or sheet pile installation and removal will be minor and temporary and the bottom substrate will return to an undisturbed condition soon after work is completed. Hydroacoustic noise impacts will affect up to 7.5 percent of channel width, and will not impede the migratory corridor PBF of any of the designated critical habitats. Noise impacts from elevated SELs will affect less than 30 percent of the channel width over the course of 1 day. This will occur during the in-water work window when species are less likely to be present, and will not affect any PBFs long-term. Therefore, the proposed Project is not likely to adversely affect critical habitat in the action area because the impacts to PBFs are minimal and temporary.

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 the Corps and NMFS. Other interested users could include the City of Rio Vista, USFWS, and CDFW. Individual copies of this opinion were provided to the Corps. 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.

4. REFERENCES

Arkoosh, M. R., E. Casillas, E. Clemons, A. N. Kagley, R. Olson, P. Reno, and J. E. Stein. 1998. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10(2): 182-190.

Bash, J., C. H. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. University of Washington Water Center. 74 pp.

Brooks, M. L., E. Fleishman, L. R. Brown, P. W. Lehman, I. Werner, N. Scholz, C. Mitchelmore, J. R. Lovvorn, M. L. Johnson, D. Schlenk, S. van Drunick, J. I. Drever, D. M. Stoms, A. E. Parker, and R. Dugdale. 2012. Life Histories, Salinity Zones, and Sublethal Contributions of Contaminants to Pelagic Fish Declines Illustrated with a Case Study of San Francisco Estuary, California, USA. Estuaries and Coasts 35(2):603-621.

Burau, J., A. Blake, and R. Perry. 2007. Sacramento/San Joaquin River Delta regional salmon outmigration study plan: Developing understanding for management and restoration.

California Department of Boating and Waterways. 2003. Sacramento - San Joaquin Delta Boating Needs Assessment 2000-2020. California Department of Parks and Recreation.

California Department of Finance. 2018. California's Population Increases by 215,000, Continuing State's Moderate Growth Rate. Sacramento, California.

California Department of Fish and Game. 1998. A Status Review of the Spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. Candidate Species Status Report 98-01.

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

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

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

California Department of Fish and Wildlife. 2018. GrandTab Spreadsheet Chinook Salmon Escapement in the Central Valley. Fisheries Branch.

California Department of Transportation (Caltrans). 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. D. o. E. Analysis, 532 pp.

California Storm Water Quality Association (2015). Best Management Practice Handbook. Menlo Park, California.

Caltrans. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. pp. 532.

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

Davis, J., W. Heim, A. Bonnema, B. Jakl, and D. Yee. 2018. Mercury and Methylmercury in Fish and Water from the Sacramento-San Joaquin Delta August 2016 – April 2017 Delta Regional Monitoring Program. 54 pp.

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

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

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

Gregory, R. S. 1993. Effect of turbidity on the predator avoidance behaviour of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fishery and Aquatic Sciences 50: 241-246.

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

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

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An Evaluation of Stocking Hatchery-Reared Steelhead Rainbow Trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River System. Fish Bulletin 114:74.

Hanson, C. H. 2009. Striped Bass Predation on listed Fish within the Bay-Delta Estuary and Tributary Rivers: Expert Report Coalition for a Sustainable Delta et al. v. Koch, E.D. Cal. Case No. CV 08-397-OWW.

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

Herbold, B., S. M. Carlson, and R. Henery. 2018. Managing for Salmon Resilience in California's Variable and Changing Climate. San Francisco Estuary and Watershed Science 16(2):23.

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

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

IPCC. 2018. Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Intergovernmental Panel on Climate Change.

Johnson, L. L., T. K. Collier, and J. E. Stein. 2002. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. Aquatic Conservation: Marine and Freshwater Ecosystems 12: 517-538.

Kemp, P., D. Sear, A. Collins, P. Naden, and I. Jones. 2011. The impacts of fine sediment on riverine fish. Hydrological Processes 25(11): 1800-1821.

Leatherbarrow, J. E., L. J. McKee, D. H. Schoellhamer, N. K. Ganju, and A. R. Flegal. 2005. Concentrations and loads of organic contaminants and mercury associated with suspended sediment discharged to San Francisco Bay from the Sacramento-San Joaquin River Delta. San Francisco Estuary Institute, Oakland, California.

Lehman, P. W., S. J. Teh, G. L. Boyer, M. L. Nobriga, E. Bass, and C. Hogle. 2010. Initial impacts of *Microcystis aeruginosa* blooms on the aquatic food web in the San Francisco Estuary. Hydrobiologia 637(1):229-248.

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

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

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

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

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

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. Canadian Journal of Fisheries and Aquatic Sciences 72(11):1749-1759.

Mora, E., R. Battleson, S. Lindley, M. Thomas, R. Bellmer, L. Zarri, and A. Klimley. 2017. Estimating the annual spawning run-size and population size of the Southern Distinct Population Segment of Green Sturgeon *(Acipenser medirostris)*. Transactions of the American Fisheries Society 147:195-203.

Mount, J. F. 1995. California Rivers and Streams: The Conflict between Fluvial Process and Land Use. University of California Press.

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

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of special concern in California, 2nd edition. California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 277 pp.

Myrick, C. A. and Joseph J. Cech Jr. (1998). "Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations." Bay-Delta Modeling Forum: 59 pp.

National Marine Fisheries Service. 2009a. Long-Term Operations of the Central Valley Project and State Water Project Biological Opinion. U.S. Department of Commerce. Long Beach, California. 844 pp.

National Marine Fisheries Service. 2009b. NMFS Pile Driving Calculator.

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

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

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

National Marine Fisheries Service. 2016c. 5-Year Status Review: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon ESU. U.S. Department of Commerce, 41 pp.

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

National Marine Fisheries Service. 2018b. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*). National Marine Fisheries Service. Sacramento, California. 95 pp.

National Marine Fisheries Service. 2019. Winter-Run Chinook Salmon Juvenile Production Estimate for Brood Year 2018.

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

Paul, M. J. and J. L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32: 333-365.

Perry, R. W., R. A. Buchanan, and P. Brandes. 2016. Anadromous Salmonids in the Delta: New Science 2006–2016. San Francisco Estuary and Watershed Science, 10(3) 14(2).

Perry, R. W. and J. R. Skalski. 2008. Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento – San Joaquin River Delta During the Winter of 2007-2008. University of Washington, Seattle, Washington.

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

Popper, A. N. and M. C. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4(1):43-52.

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

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

Scott, G. R. and K. A. Sloman. 2004. The effects of environmental pollutants on complex fish behavior: integrating behavioural and physiological indicators of toxicity. Aquatic Toxicology 68: 369-392.

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

Stewart, A. R., S. N. Luoma, C. E. Schlekat, M. A. Doblin, and K. A. Hieb. 2004. Food web pathway determines how selenium affects aquatic ecosystems: A San Francisco Bay case study. Environmental Science and Technology 38(17):4519-4526.

Suttle, K. B., M. E. Power, J. M. Levine, and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological applications 14(4): 969-974.

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

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

U.S. Fish and Wildlife Service. 2000. Impacts of Riprapping to Ecosystem Functioning, Lower Sacramento River, California. U.S. Fish and Wildlife Service. 15 pp.

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

U.S. Fish and Wildlife Service. 2016. Delta Juvenile Fish Monitoring Program (DJFMP): 2000-2016 Monitoring Data. https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm.

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

Vogel, D. 2008. Evaluation of Adult Sturgeon Migration at the Glenn-Colusa Irrigation District Gradient Facility on the Sacramento River. Natural Resource Scientists, Inc., Red Bluff, California.

Vogel, D. 2011. Evaluation of Fish Entrainment in Seven Unscreened Sacramento River Diversions 2010. Natural Resource Scientists, Inc., Red Bluff, California.

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

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

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