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

Refer to NMFS No: WCR-2018-9080

March 18, 2018

Mr. William Guthrie
Chief
California Delta Section, Regulatory Division
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the 2018 – 2022 South Delta Temporary Barriers Program

Dear Mr. Guthrie:

Thank you for your November 16, 2017, letter, received by NOAA's National Marine Fisheries Service (NMFS) on November 21, 2017, requesting initiation of consultation with NMFS pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the 2018 – 2022 South Delta Temporary Barriers Program (TBP).

This letter transmits NMFS programmatic biological opinion (Enclosure 1) based on our review of the proposed construction and operation of the South Delta TBP in San Joaquin County for the 2018 - 2022 operational seasons by the California Department of Water Resources (DWR), and its effects on federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and the designated critical habitat of California Central Valley steelhead and Southern DPS of North American green sturgeon in accordance with section 7 of the ESA, as amended (16 U.S.C. 1531 et seq.).

This programmatic biological opinion is based on information provided by DWR (the project applicant), and a literature review completed by NMFS staff. A complete administrative record of this consultation is on file at the NMFS California Central Valley Office. Based on the best available scientific and commercial information, the programmatic biological opinion concludes that the installation and operation of the South Delta TBP over the next 5 years is not likely to jeopardize the continued existence of the above listed species or adversely modify or destroy designated critical habitats. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take of listed anadromous fish species associated with the South Delta TBP.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action. Conservation Recommendations for Pacific salmon EFH are also enclosed as required by the MSA as amended (16 U.S.C. 1801 et seq. This document concludes that construction of the South Delta TBP will adversely affect EFH of Pacific salmon in the action area and adopts the ESA reasonable and prudent measures and associated terms and conditions from the biological opinion as well as the recommendations in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan as the EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the U.S. Army Corps of Engineers (Corps) to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH Conservation Recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920[j]). In the case of a response that is inconsistent with NMFS recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

We appreciate your continued cooperation in the conservation of listed species and their habitat, and look forward to working with you and your staff in the future. Please contact Douglas Hampton of my staff at (916) 930-3610, or via e-mail at Douglas.Hampton@noaa.gov, if you have any questions or require additional information concerning the South Delta TBP.

Sincerely,

Maria Rea
for

Barry A. Thom
Regional Administrator

Enclosure

cc: Copy to file: ARN # 151422-WCR2018-SA00418

Mr. Jacob McQuirk, California Department of Water Resources, 1416 Ninth Street, P.O. Box 942836, Sacramento, California 94236-0001

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

2018 – 2022 South Delta Temporary Barriers Program

NOAA's National Marine Fisheries Service (NMFS) Consultation Number: *WCR-2018-9080*

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?
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	Endangered	Yes	No	N/A	
Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	N/A	
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Southern distinct population segment of North American Green Sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	Yes	No

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

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

Maria Rea

PIssued By: ______________________________

Barry A. Thom
Regional Administrator

Date: March 18, 2018

TABLE OF CONTENTS

1. INTRODUCTION 3
1.1 Background.... 3
1.2 Consultation History.... 3
1.3 Proposed Federal Action 5
2. ENDANGERED SPECIES ACT: 14
2.1 Analytical Approach.... 14
2.2 Rangewide Status of the Species and Critical Habitat 16
2.3 Action Area 25
2.4 Environmental Baseline.... 26
2.5 Effects of the Action.... 31
2.6 Cumulative Effects 46
2.7 Integration and Synthesis 47
2.8 Conclusion.... 52
2.9 Incidental Take Statement 52
2.9.1 Amount or Extent of Take 52
2.9.2 Effect of the Take 54
2.9.3 Reasonable and Prudent Measures 54
2.9.4 Terms and Conditions.... 54
2.10 Conservation Recommendations 56
2.11 Reinitiation of Consultation 56
3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE....57
3.1 Essential Fish Habitat Affected by the Project.... 57
3.2 Adverse Effects on Essential Fish Habitat 58
3.3 Essential Fish Habitat Conservation Recommendations.... 58
3.4 Statutory Response Requirement 59
3.5 Supplemental Consultation.... 60
4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW ..60
5.1 Utility.... 60
5.2 Integrity 60
5.3 Objectivity 60
5. REFERENCES 61

1. INTRODUCTION

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

1.1 Background

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

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

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources, and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661 et seq.).

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

1.2 Consultation History

The regulatory permit history of the Temporary Barriers Program began in 1991 and includes many separate consultations, take authorizations, and permits from the U.S. Army Corps of Engineers (Corps), the U.S. Fish and Wildlife Service (FWS), NMFS, the California Department of Fish and Wildlife (CDFW), and the Central Valley Regional Water Quality Control Board (CVRWQCB). California Department of Water Resources (DWR) is currently pursuing a multi-year permit from the Corps under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act to cover the construction, operation, and removal of the Temporary Barriers Program during water years 2018–2022.

The recent consultation history for the Temporary Barriers Program is as follows:

- In 2008, NMFS issued a biological opinion for the construction of the Temporary Barriers Program (NMFS # 2007/07586).
- In 2009, NMFS issued a biological opinion for the construction of a non-physical barrier at the head of Old River (NMFS # 2009/01239).
- In 2011, NMFS issued a biological opinion that addressed the effects of construction of

the four rock barriers and the non-physical barrier at the head of Old River (NMFS # 2010/06485). This biological opinion expired on December 31, 2011.

- In 2012, NMFS issued a biological opinion for the installation of the temporary barriers program (NMFS File # 2012/00152; NMFS 2012), which included the construction and removal of the four rock barriers.
- In 2012, the Corps modified the 2001 Temporary Barriers Project—Agricultural Barriers, Clean Water Act Section 404 permit (SPK # 200100121) with the updated 2012 schedule for the construction of three rock barriers.
- In 2012, the Corps modified the 2000 Temporary Barriers Project—Head of Old River Rock Barriers, Clean Water Act Section 404 permit (SPK # 200000696) with the updated 2012 project description and schedule for the construction of the spring and fall rock barriers at the head of Old River.
- In 2012, the CVRWQCB amended the Clean Water Act Section 401 Water Quality Certification for the construction and removal of the four rock barriers and construction and removal of the non-physical barrier at the head of Old River (WDID # 5B39CR00191).
- In 2013, NMFS issued a programmatic biological opinion for the proposed construction and operation of the Temporary Barriers Program for 2013-2017 (NMFS File # 2012/9347).
- In 2013, the Corps sent a letter to DWR authorizing construction of the 2013 agricultural barriers (SPK-2001-00121).
- In 2016, DWR requested that the CVRWQCB renew the Section 401 Water Quality Certification (WDID # 5B39CR00191).
- In 2016, DWR requested extension of the CDFW Lake and Streambed Alteration Agreement (file # 1600-2010-0375-R3) and extension of the California Endangered Species Act Incidental Take Permit (#2801-2011-019-03); CDFW indicated that this agreement and permit will be extended to 2021 (pending agreement on cost of additional mitigation measures for the ITP).
- On November 21, 2017, NMFS received a letter dated November 16, 2017, from the Corps requesting the initiation of consultation pursuant to section 7 of the ESA in support of the issuance of two Department of the Army permits to DWR for the 2018-2022 annual construction and removal of Temporary Agricultural Barriers and the Head of Old River Temporary Barrier projects (SPK-2001-00121 and SPK-2000-00696). NMFS determined that the November 21, 2017, Corps request and supporting documentation was sufficient to initiate formal section 7 consultation.

This biological opinion analyzes the effects of the 2018 – 2022 South Delta Temporary Barriers Program (TBP) on Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), California Central Valley (CCV) steelhead (*O. mykiss*), the Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and the designated critical habitats for CCV steelhead and the Southern DPS of North American green sturgeon. A complete administrative record is located at the NMFS California Central Valley Office.

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). Similarly, the definition of a Federal action pursuant to the MSA means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

Under the FWCA, an action occurs whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, or by any public or private agency under Federal permit or license" (16 USC 662(a)).

"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 interdependent or interrelated activities associated with the proposed Federal action.

Overview

The TBP refers to the annual installation, maintenance, and removal of up to four rock barriers in the channels of the southern portion of the Sacramento-San Joaquin Delta near the cities of Tracy and Lathrop in San Joaquin County, California. The TBP was initiated in 1991 in response to a lawsuit filed by the South Delta Water Agency (SDWA) in 1982 against DWR. DWR agreed to install these barriers to ensure that local agricultural diverters within the SDWA did not experience adverse water level and circulation impacts caused by the State Water Project (SWP) and Central Valley Project (CVP). All of the barriers are typically installed during the period between March and November each year. Three of the barriers facilitate pumping by agricultural water diversions for irrigation purposes, and the Head of Old River barrier provides a measure of protection for anadromous fish species migrating through the San Joaquin River corridor. None of the barriers can be constructed when ambient flows in the San Joaquin River exceed 5,000 cubic feet per second (cfs) as measured at the Vernalis monitoring station, as high flows create extremely hazardous and unsafe working conditions, and further complicate the placement of rocks in the channel due to the likelihood of those rocks becoming dislodged and/or displaced as a result of those higher flows.

Each year DWR installs three agricultural rock barriers: one in Old River near Tracy (ORT), another in Middle River (MR), and a third in the Grant Line Canal (GLC) near the Tracy Boulevard Bridge. These barriers are designed to act as flow control structures, "trapping" tidal waters behind them following a high tide in order to improve water levels and circulation for local south Delta farmers. A fourth barrier, installed at the Head of Old River (HOR), is designed to improve conditions for all migrating anadromous salmonid species originating in the San Joaquin River watershed during adult and juvenile migrations (i.e., fall and spring) by "blocking" migratory movements into the Old River channel from the mainstem San Joaquin River. As this fourth barrier at the HOR serves a different purpose than the other three, its utility to program implementation goals each year is assessed according to the environmental conditions that exist for that year, independently of the need to install the other three agricultural barriers previously mentioned.

The TBP has been ongoing for over 20 years currently, and the permitting process has varied from year to year as the program has grown and evolved through the incorporation of new technologies and scientific information, the accumulation of knowledge and understanding gleaned from the continuing analyses performed on an ever expanding data set, and the lessons learned from the practical experience of implementing the program each year over the past two decades. Owing to these improved understandings and efficiencies in the annual implementation of the TBP, and in the interest of streamlining government agency coordination and permit processing, this biological opinion will consider the potential effects to federally listed anadromous fish species resulting from the annual implementation of the TBP over a 5-year period from water year 2018 through water year 2022. Therefore, this project description will define the parameters for the installation and removal of all four barriers on an annual basis. Variation within those parameters will also be considered annually according to the specific conditions encountered in any given year.

Facilities Description

1. <u>Middle River (MR)</u>

The MR barrier is located about a half mile south of the confluence of Middle River, Trapper Slough, and North Canal. The MR barrier is a rock barrier constructed with a center weir section that allows tidal flows to enter the Middle River upstream of the barrier by overtopping the weir crest and flowing through submerged culverts that have tidally operated flap-gates on their upstream end. The tidal flow is partially retained behind the barrier during the ebb tide by the barrier elevation and the closure of the flap-gates. This allows agricultural pumps to operate throughout each tidal cycle by maintaining a minimum water elevation of 2.6 feet measured at the Howard Road Bridge station.

Each year the MR barrier weir section is constructed by placing approximately 2,300 cubic yards (cy) of rock between the two previously constructed abutments that are left in place year-round. Each abutment has three, 48-inch diameter culverts with tidally-operated flap-gates that are also left in place. Placement of rock completes the barrier that is 270-feet long and 50 feet-wide (0.31 acre). The rock weir section is 140-feet long and 18-feet wide at a crest elevation of 3.3 feet above mean sea level (msl). By September 15th, a 10 foot-wide notch (fall notch) is constructed in the weir for salmon passage. The notch allows a minimum depth of 6 inches of water to pass over the barrier during low-high tide events and remains in place until the barrier is removed. Additionally, in an effort to meet and maintain water quality standards pertaining to salinity and dissolved oxygen set by the State Water Resources Control Board and the CVRWQCB, DWR retains the option to raise the height of the MR barrier center weir by an additional one foot, from 3.3 feet to 4.3 feet above msl, during peak irrigation months. This is designed to trap more of the freshwater found below the barrier, thereby improving the water quality upstream from the barrier. Raising the MR barrier in conjunction with tying open the ORT barrier culvert flap-gates is intended to create net circular flow up Middle River and down Old River, which would decrease zones of stagnant water. Raising the height of the MR barrier center weir one foot will require an additional 100 cy of rock and will reduce the width of the crest to 15 feet, but is not expected to change the overall footprint of the MR barrier. The MR barrier will only be raised when risks to delta smelt have passed and in coordination with the FWS and CDFW. The center weir section of the MR barrier is removed during the non-irrigation season (December through March). The flap-gates are tied open when the center weir section is removed. The fall notch in the MR barrier will remain the same elevation regardless of the one foot increase in weir height. The notch will be 10 feet wide and at an elevation of 2.6 feet above msl. While the culverts are left in place for most years, periodic culvert replacement may occur every 10 – 15 years in order to ensure their functionality. Culvert replacement at the MR barrier is not likely to be required during the 2018-2022 period however.

2. Old River near Tracy (ORT)

The ORT barrier is located near the CVP's Tracy Fish Collection Facility (TFCF) on Old River, approximately 0.5 miles east of the CVP's inlet. The structure allows tidal flows to enter the channel upstream of the barrier by overtopping the weir crest and flowing through the submerged culverts. The tidal flow is then partially retained during the ebb tide by the barrier elevation and the closure of tidal flap-gates on the upstream side of each culvert.

Each year, construction of the ORT barrier may begin as early as May 1 and must be removed by November 30. Construction at ORT begins with placement of a rock and gravel pad followed by the placement of three metal culvert frames on the prepared pad, each containing three 60-foot long, 48-inch diameter culverts (nine culverts total) with tidally operated flap-gates on the upstream end, 1 foot apart from each other. The culverts are then covered with approximately 5,000 cy of rock to form a 250-foot long berm that is 60 feet wide at its base (0.34 acre). The center of the barrier has a 75-foot wide weir with a crest elevation of 4.4 feet above msl. During summer months, some of the flap-gates may be tied to the open position to improve circulation in this area. Tying the flap gates open in conjunction with the Middle River raise is intended to increase net downstream flow and reduces stagnant zones in Old River. A temporary boat ramp is constructed with riprap at the base, followed by crushed rock, and topped with articulated concrete mats. Because much of the boat ramp structure will be underwater, divers will aid in the positioning of the concrete mats. Similarly to the MR barrier, a 10-foot-wide notch is constructed by September 15 each fall to allow adult salmon passage.

3. Grant Line Canal (GLC)

The GLC barrier is located on Grant Line Canal east of Tracy Boulevard approximately 4 miles north of the City of Tracy. Construction of the GLC barrier may begin as early as May 1 each year, with removal being completed by no later than November 30. The GLC barrier is constructed with approximately 12,600 cy of rock that is placed between the existing south abutment and the north canal bank to create a 300-foot long barrier that is up to 100 feet wide at its base (0.69 acre). The center of the barrier has a weir section with a crest elevation at 3.3 feet above msl that is 125 feet long and 24 feet wide. The existing south abutment contains six 48-inch diameter, 60-foot long culverts with flap-gates on the upstream end. A catwalk structure is affixed to the top of each culvert with a winch and hand crank allowing access to and operation of the flap-gates attached to the upstream end of each culvert. A 10-foot wide flashboard structure is also built at the south abutment which can be adjusted to allow delta smelt passage in the spring and salmonid passage in the fall. Similarly to the ORT barrier, a ramped boat portage facility is also provided at the north levee. The boat ramp is constructed with riprap at the base, followed by crushed rock, and topped with articulated concrete mats. Because much of the boat ramp structure will be underwater, divers will aid in the positioning of the concrete mats. While the culverts are left in place for most years, periodic culvert replacement may be required every 10 – 15 years in order to ensure their functionality. Culvert replacement at the GLC barrier is not likely to be required during the 2018-2022 period, however.

4. <u>Head of Old River (HOR)</u>

The HOR barrier is located at the divergence of Old River from the San Joaquin River near the City of Lathrop. The HOR barrier serves a dual purpose and may be installed in both the spring and the fall. In the spring, the barrier acts as a fish barrier to decrease the number of salmonid smolts entering Old River as they migrate through the Delta to the ocean. In the fall, the barrier may be needed to increase flows and dissolved oxygen levels downstream in the San Joaquin River, including the Stockton deepwater shipping channel.

a. *Spring HOR Barrier*

The spring HOR barrier is intended to prevent downstream-migrating salmonid smolts in the San Joaquin River from entering Old River, which would expose them to SWP and CVP diversion operations and unscreened agricultural diversions. Construction of the spring HOR barrier may begin as early as March 1 each year, with removal of this barrier to be completed by no later than May 31. The spring HOR barrier is constructed with approximately 12,500 cubic yards of rock to form a 225-foot long, 85-foot wide berm at its base (0.44 acre). The spring HOR barrier has a crest elevation of 12.3 feet above msl. Construction at the south end of the barrier includes the placement of up to eight 48-inch diameter culverts with slide-gates into the barrier abutment. The middle section includes a 75-foot clay weir at an elevation of 8.3 feet above msl that is capped with clay up to the barrier crest elevation. Unlike the ORT and GLC barriers, there is no boat portage facility at this barrier. A ramp and dock may be secured to the shore in order to allow storage and safe access to small boats that may be used for construction, maintenance, and research purposes.

b. *Fall HOR Barrier*

The fall HOR barrier is constructed annually beginning any time after September 1 each year, with removal being completed by November 30. Construction of the fall HOR barrier proceeds similarly to the construction of the spring HOR barrier, but will be composed of approximately 7,500 cubic yards of quarry rock to form a slightly smaller berm which will measure roughly 225 feet long, 65 feet wide at its base (0.34 acre), have a crest elevation of 8.3 feet above msl, and includes up to eight 48-inch operable culverts with slide gates. In addition, a small 30-foot wide notch will be constructed in the barrier’s middle section with a crest elevation of +2.3 feet msl. This notch is designed to facilitate upstream movement of adult salmon that may move through the Old River system of channels back into the main stem of the San Joaquin River.

Construction, Operation, and Removal of the Barriers

The TBP entails the annual placement of up to four barriers within the channels of Old River near Tracy (ORT; 37.8103 N, -121.5428 W), Middle River (MR; 37.8857 N, -121.4822 W), Grant Line Canal (GLC; 37.8199 N; -121.4483 W), and at the head of Old River near its divergence from the San Joaquin River (HOR; 37.8078 N, -121.3307 W). Quarry rock is stockpiled alongside the sections of river adjacent to the barrier installation sites on the waterside of the levee crown. Each spring, heavy construction equipment is mobilized to move the stockpiled rock from its storage location adjacent to the river channel and into the channel to form the barriers. Large front loaders, dump trucks, and long-reach excavators are used to move and place the materials. Typically, machinery works from both banks of the channel to place the rock material, as well as any additional materials such as culverts, flashboard structures, concrete reinforcing mats, or other structures. Depending on the individual design of each barrier, the 48-inch diameter steel pipes used as culverts are placed by crane after the bed of the barrier is constructed. If the barrier abutments remain in place over the winter, the culverts are typically left in place also. As the rock barrier is extended into the channel, machinery can utilize the crown of the barrier to move farther into the channel on top of the barrier to place additional materials. Each of the barriers is adequately marked with navigational aids and warning signs approved for placement by the U.S. Coast Guard (Private Aids Permit #s 2832-2839).

Construction typically takes between 1-3 weeks to complete for each barrier. Barrier installation, including in-water work and associated construction activities such as mobilization and site clean-up, typically requires approximately 24 working days for the spring HOR barrier, 18 working days for the fall HOR barrier, 5 working days for the MR barrier, 20 working days for the ORT barrier and 24 working days for the GLC barrier. However, extreme weather, tide, and river flow conditions may impact the barriers completion date. Construction activities for all of the barriers would begin no sooner than March 1 of any given year, and removal would be completed no later than November 30 of each year. Any barrier operating on or after September 15 will be notched beginning on that date in order to allow for passage of adult salmon. At GLC, flashboards will be removed to create the notch in the barrier. The HOR barrier cannot be constructed when ambient flows in the San Joaquin River exceed 5,000 cfs, as measured at the Vernalis flow monitoring station. In addition, DWR proposes to continue implementing standard best management practices (BMPs) during the annual in-water construction and removal activities in order to effectively minimize and/or avoid potential impacts to listed species and their habitats. Some of these measures include the preparation and adherence to an erosion control plan, a spill prevention and control plan, and a hazardous materials management plan, in addition to conducting worker environmental awareness training, utilization of silt fences, straw waddles, and other devices intended to prevent or reduce the potential for sediments to be introduced into the aquatic environment.

Removal of the barriers will occur in the fall and the installation procedure is reversed. Barrier removal, including in-water work, and associated construction activities such as mobilization and site clean-up, typically takes approximately 24 working days for the spring HOR barrier, 18 working days for the fall HOR barrier, 5 working days for the MR barrier, 20 working days for the ORT barrier and 21 working days for the GLC barrier. The barriers will be removed with an excavator and a dragline. An excavator will remove the majority of the rock down to the underwater pad of the culvert frames. Because the culvert pad is longer and wider than the reach of the excavator, a dragline with a bucket will be necessary to remove the remainder of the underwater rock associated with the barriers. The removed rock is stockpiled outside of the waterway until used again. At the barrier sites, the channel bottom is restored to pre-project conditions after the barriers are removed. Confirmation that the channel bottom has been restored to pre-project conditions is accomplished via bathymetric surveys which are conducted each year before construction (pre-project) and after removal. The barrier culverts and abutments at MR will remain in place throughout the year, as will the culverts and south barrier abutment at GLC.

While the culverts are left in place for most years at MR and GLC, periodic culvert replacement may be required in order to ensure their functionality. Removal of the culverts would occur during the fall barrier removal. The removal of the culverts and the abutments at MR and GLC would add approximately 10 days for GLC and 5 days for MR to the removal schedule. The culverts and their associated structures would then be repaired or replaced and reset into the normal position using similar techniques to the culvert placement at ORT. Culvert replacements would occur during the spring barrier installation, and would add approximately 10 days of work for GLC and 5 days for MR. The normally permanent rock abutments in each of these locations would be rebuilt as they have been previously constructed. The culverts at MR and GLC barriers have been replaced in recent years, however, and are not likely to require replacement during the 2018-2022 period. Nevertheless, consideration is given to the possibility of repair work being required due to unforeseen circumstances, and the additional days for conducting the culvert replacement work are assumed to be part of the proposed action.

The spring HOR barrier may be operated from April 1 through May 31 and installation of the fall HOR barrier will be at the timing and recommendation of the CDFW, NMFS and FWS based on dissolved oxygen levels in the San Joaquin River. The spring and fall HOR barriers will be installed and operated following the criteria listed in Table 1.

Table 1. HOR barrier installation and operation schedule.

Schedule	**Activity**
March 1	Spring installation of rock barrier may begin.
April 1-May 31	Full closure and/or operation of the spring barrier may occur.
	If a barrier at HOR is installed and 1) the GLC barrier is breached due to Delta Smelt concerns **OR:** 2) the GLC barrier cannot be closed when the need is clearly demonstrated by DWR, the HOR barrier must be breached and removed as soon as possible, unless otherwise instructed by the CDFW, NMFS and FWS.
May 15-May 31	Full closure and/or operation may continue, at the discretion of the CDFW, NMFS and FWS.
On or after September 1	Fall barrier installation may begin at the discretion of CDFW, NMFS and FWS.
November 30	Barrier must be completely removed.

The three agricultural barriers are installed and operated based on the spring HOR barrier installation. If the spring HOR barrier is not installed, the agricultural barriers will be installed and operated following the schedule in Table 2. If the spring HOR barrier is installed, then the agricultural barriers will be installed and operated following the schedule in Table 3.

Table 2. Agricultural Barrier installation and operation schedule, for years when the spring HOR barrier is not installed.

	MR	**ORT**	**GLC**
May 1	Installation may begin.	Installation may begin.	Installation may begin.
May 15 to May 31	Full operation and closure may occur if: • the need for MR full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data shall be provided to the CDFW, NMFS and FWS 1 week in advance of closing the flapgates).	Full operation and closure may occur if: • the need for ORT full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data will be provided to the CDFW, NMFS and FWS 1 week in advance of closing the flapgates).	Full operation of flapgates and/or closure of the center rock section may occur if: 1) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data will be provided to the CDFW, NMFS and FWS 2 weeks in advance of closing the flapgates and center sections of the barrier). **AND:** 2) the incidental take concern level for Delta Smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect Delta Smelt, the CDFW, NMFS and FWS may require the flap gates to be tied in the open position and the center section of the barrier to be removed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with CDFW and FWS approval.	Full operation and closure may occur.	Full operation of flapgates and/or closure of the center rock section may occur. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect delta smelt, the CDFW, NMFS and FWS may require the flap gates to be tied in the open position and the center section of the barrier to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Table 3. Agricultural Barrier installation and operation schedule, for years when the spring HOR barrier is installed.

	MR	ORT	GLC
March 1	Installation may begin.	Installation may begin.	Installation may begin.
April 1 to May 31, after HOR barrier is fully operational	Full operation and closure may occur. If HOR barrier is breached, flap gates must be tied in open position.	Full operation and closure may occur. If HOR barrier is breached, flap gates must be tied in open position.	Full operation of flapgates and/or closure of the center rock section may occur if: 1) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data will be provided to the CDFW, NMFS and FWS two weeks in advance of closing the flap gates and center sections of the barrier). **AND:** 2) the CDFW, NMFS and FWS, in coordination with DWR, approves closure. If HOR is breached, flap gates must be tied in open position. If HOR is breached due to Delta Smelt concerns, flap gates must be tied in the open position and the center section of the barrier shall be removed until concerns have passed.
June 1 to November 30	Full operation and closure may occur. Barrier elevation can be raised from 3.3 feet NAVD to 4.3 feet NAVD with CDFW and FWS approval.	Full operation and closure may occur.	Full operation of flapgates and/or closure of the center rock section may occur if: 1) the need for GLC full operation is clearly demonstrated by DWR through forecasting water levels by delta modeling and by actual stage data collected in the field (such data will be provided to the CDFW and FWS 1 week in advance of closing the flap gates and center sections of the barrier). **AND:** 2) the incidental take concern level for Delta Smelt at the SWP/CVP facilities has not been reached. If the incidental take concern limit is reached at the SWP/CVP facilities and if reductions in project exports are determined to be inadequate to protect Delta Smelt, the CDFW and FWS may require the flap gates to be tied in the open position and the center section to be removed.
September 15	Barrier must be notched to allow passage of adult salmon.	Barrier must be notched to allow passage of adult salmon.	Barrier must have enough flashboards removed to allow passage of adult salmon.
November 30	Barrier must be completely removed.	Barrier must be completely removed.	Barrier must be completely removed.

Fish Monitoring Studies

Annual implementation of the TBP may also include specific program elements such as fish monitoring studies that will vary from year to year in the way that they are carried out. Some of these program elements may include activities such as the tagging and releasing of hatchery-raised salmon and steelhead in the south Delta, installing an acoustic receiver network with a two-dimensional (2-D) biotelemetry system, implementing a mobile monitoring effort to find acoustic tags on the river bottom using a global positioning system, monitoring fish using Dual-Frequency Identification Sonar (DIDSON) cameras, placement of hydroacoustic and other scientific instrumentation, and sampling, tagging, and releasing predatory fish. Additional studies of salmonid smolts and predatory fish may be conducted; however, techniques used to capture predatory fish would be limited to electrofishing, hook and line sampling, fyke net trapping, tangle nets, and purse/beach seines.

The following study techniques have been used in the past and are likely to be used again during the 2018-2022 operational seasons.

- 2-D tracking of acoustically tagged Chinook salmon and steelhead smolts in the vicinity of the HOR barrier.
- 2-D tracking of acoustically tagged predatory fish in the vicinity of the HOR barrier.
- Acoustic tagging of salmonid smolts and predatory fish.
- Capture of predatory fish using multiple techniques.
- Placement of a 2-D hydrophone array within 0.5 mile of barrier locations.
- Placement of hydrophone nodes at strategic locations within the south Delta (e.g., peripheral nodes to determine migration paths).
- Placement of Acoustic Doppler Current Profilers (ADCPs) within 0.5 mile of barrier locations.
- Placement of DIDSON cameras within 0.5 mile of barrier locations.
- Mobile hydroacoustic monitoring in the south Delta.

As they are developed, advanced technologies and monitoring techniques may be used in the future. Fish studies may not be conducted in all years. Specific study plans and effects analyses for carrying out fish monitoring studies associated with implementation of the TBP in any given year would be prepared and submitted to the Corps separate ESA section 7 consultation.

An acoustic telemetry tracking system consisting of hydrophone arrays may be used to monitor juvenile salmonids and predatory fish. Juvenile salmonids obtained from local hatcheries (e.g., Mokelumne River Fish Hatchery) are surgically implanted with bio-acoustic tags and then released upstream from the barriers. Each acoustic tag transmits an underwater sound signal (i.e., acoustic “ping”) that sends identification information about the tagged fish to strategically placed hydrophones, onshore receivers, data loggers, and data processing computers that detect and record the location of the tagged fish as they move through the study area. Up to 50 hydrophones may be deployed in the rivers to detect the tagged fish. Each hydrophone is secured to an anchor made from a short section of railroad track with a section of rope and a floating buoy. The data are analyzed to determine how juvenile salmonids interact with the barrier and predatory fish behavior. The tracking system includes an array to collect 2-D tracks around the barriers and several other hydrophone node placements farther from the barriers to determine the fates of tagged fish.

DIDSON cameras may be installed with weighted stands or attached to structures associated with a barrier. DIDSON cameras are intended to monitor fish behavior around the barrier and to obtain data to achieve defined study objectives. The objectives may include gaining a better understanding of how predatory fish interact with the barrier, how other fish interact with the barriers, predation events near the barriers, and how juvenile salmonid response to the barriers. DIDSON cameras would be placed within 0.5 mile of the barriers. No more than 10 weighted stands would be installed during any study year. Each weighted stand would occupy approximately 1 square foot of streambed.

Construction activities associated with the fish studies are expected to be minimal, but are likely to require the placement of anchors, weighted stands, and cabling, as just described, in any given year they are conducted. Scientific equipment is affixed to several types of mounting brackets depending on equipment type, barrier type, and location. Up to 50 anchors made from sections of railroad track or similar weighted anchors are used to anchor floating scientific equipment, such as hydrophones placed in the water column and attached to anchors with tensioned lines. Each anchor occupies approximately 0.6 square foot of streambed. Additionally, up to 10 weighted stands are used for placing stationary equipment such as ADCPs and DIDSON cameras. The minimum required number of railroad track anchors and weighted stands would be placed each year and scientific equipment would be attached to docks or culvert gate catwalks whenever possible. All scientific equipment would be affixed to anchors and stands similar in nature and impact to those used for ADCPs, DIDSON cameras, and hydrophones.

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.

2.1 Analytical Approach

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

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

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

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

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

This opinion assesses the effects of the annual implementation of the TBP over a 5-year period on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, the threatened Southern DPS of North American green sturgeon, and designated critical habitat for CCV steelhead and the Southern DPS of North American green sturgeon. To conduct this assessment, NMFS examined information from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, government and non-government reports, the Programmatic biological assessment for the 2018 - 2022 TBP, and supplemental material provided by DWR during the course of the consultation, including reports and results emanating from fish studies and monitoring conducted in conjunction with the implementation of the TBP in past years.

2.2 Rangewide Status of the Species and Critical Habitat

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

The following federally listed species evolutionarily significant units (ESU) or distinct population segments (DPS) and designated critical habitats occur in the action area and may be affected by the proposed TBP:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
Listed as endangered (70 FR 37160, June 28, 2005)

Central Valley spring-run Chinook salmon ESU (*O. tshawytscha*)
Listed as threatened (70 FR 37160, June 28, 2005)

California Central Valley steelhead DPS (*O. mykiss*)
Listed as threatened (71 FR 834, January 5, 2006)

California Central Valley steelhead designated critical habitat
(70 FR 52488, September 2, 2005)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
Listed as threatened (71 FR 17386, April 7, 2006)

Southern DPS of North American green sturgeon designated critical habitat
(74 R 52300, October 9, 2009)

2.2.1 Sacramento River Winter-run Chinook Salmon ESU

Historically, Sacramento River winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011). In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively [California Department of Fish and Game (CDFG) 2012]. However, from 2007 to 2013, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 CDFG 2012). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009), drought conditions from 2007 to 2009, and low in-river survival rates (NMFS 2011). In 2014 and 2015, the population was approximately 3,000 adults, slightly above the 2007 to 2012 average, but below the high (17,296) for the last 10 years (CDFW 2016).

The year 2014 was the third year of a drought that increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the Red Bluff Diversion Dam (RBDD) was approximately 5 percent (NMFS 2016). Due to the anticipated lower than average survival in 2014, hatchery production from Livingston Stone National Fish Hatchery (LSNFH) was tripled (i.e., 612,056 released) to offset the impact of the drought (CVP and SWP Drought Contingency Plan 2014). In 2014, hatchery production represented approximately 83 percent of the total in-river juvenile production. In 2015, egg-to-fry survival was the lowest on record (approximately 4 percent) due to the inability to release cold water from Shasta Dam in the fourth year of a drought. As expected, winter-run Chinook salmon returns in 2016 and 2017 were both very low, estimated at 1,546 and 1,155 (CDFW 2017), respectively, due to drought impacts on juveniles from brood years 2013 and 2014 (NMFS 2016).

Although impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the winter-run Chinook salmon conservation program at LSNFH is strictly controlled by the FWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001 to 2010 average) compared to the estimated natural production that passes RBDD, which is 4.7 million per year based on the 2002 to 2010 average (Poytress and Carrillo 2011). Therefore, hatchery production typically represents approximately 3 to 4 percent of the total in-river juvenile winter-run production in any given year. However, because drought conditions were expected to result in low juvenile winter-run Chinook salmon survival in the Sacramento River, LSNFH tripled its production of juvenile winter-run in brood year 2014 and released ~600,000 juvenile winter-run Chinook salmon into the upper Sacramento River. For brood year 2015, LSNFH doubled its production, and released ~400,000 juvenile winter-run Chinook salmon into the upper Sacramento River. As a result of the increased contribution of hatchery production to total in-river production in recent years, the 2017 returns (brood year 2014) was represented by more than 70 percent hatchery influence, indicating the population is at a moderate risk of extinction.

The distribution of winter-run spawning and initial rearing historically was limited to the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration [i.e., a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery (CNFH) weir]. The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, restoring spawning and rearing habitat suitable for winter-run Chinook salmon in Battle Creek, which will be reintroduced to establish an additional population. Approximately 299 miles of former tributary spawning habitat above Shasta Dam are inaccessible to winter-run Chinook salmon. Yoshiyama et al. (2001) estimated that in 1938, the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since

2001, the majority of winter-run chinook salmon redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (National Marine Fisheries Service 2011). The winter-run Chinook salmon ESU is comprised of only one population that spawns below Keswick Dam. The remnant and remaining population cannot access 95 percent of their historical spawning habitat and must therefore be artificially maintained in the upper Sacramento River by spawning gravel augmentation, hatchery supplementation, and regulation of the finite cold water pool behind Shasta Dam to reduce water temperatures.

Winter-run Chinook salmon require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2020. The Central Valley Salmon and Steelhead Recovery Plan (Recovery Plan) includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats in Battle Creek as well as upstream of Shasta Dam (NMFS 2014). LSNFH is scheduled to release approximately 200,000 juvenile winter-run Chinook salmon into Battle Creek from its captive broodstock program during the spring of 2018 in order to jumpstart the reintroduction.

Winter-run Chinook salmon embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, which makes the species particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). Reclamation (2008) considered the effects of climate change in three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or, earlier spring snow melt. Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008, Beechie et al. 2012, Dimacali 2013). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. Underscoring the importance of habitat diversity to the resiliency of the ESU, Phillis et al. (2018) documented the reliance of an average of 58% of returning winter run adults (brood years 2007-2009) on non-natal rearing habitats. It is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2014).

There are several criteria that would qualify the winter-run Chinook salmon population to be placed at a moderate risk of extinction (continued low abundance, a negative growth rate over two complete generations, significant rate of decline since 2006, increased hatchery influence on the population, and increased risk of catastrophe), and because there is still only one population that spawns below Keswick Dam, the Sacramento River winter-run Chinook salmon ESU is at a high risk of extinction in the long term. The extinction risk for the winter-run Chinook salmon

ESU has increased from moderate risk to high risk of extinction since 2005, and several listing factors have contributed to the recent decline, including drought, poor ocean conditions, and hatchery influence (National Marine Fisheries Service 2016). Thus, large-scale fish passage and habitat restoration actions are necessary for improving the winter-run Chinook salmon ESU viability (NMFS 2016).

2.2.2 Central Valley Spring-run Chinook Salmon ESU

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

Monitoring of the Sacramento River mainstem during CV spring-run Chinook salmon spawning timing indicates some spawning occurs in the river (CDFW 2014). Genetic introgression has likely occurred here due to lack of physical separation between spring-run and fall-run Chinook salmon populations (CDFG 1998). Battle Creek and the upper Sacramento River represent persisting populations of CV spring-run Chinook salmon in the basalt and porous lava diversity group, though numbers remain low. Other Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU. Generally, these streams showed a positive escapement trend between 1991 and 2006, displaying broad fluctuations in adult abundance. The Feather River Fish Hatchery (FRFH) CV spring-run Chinook salmon population represents an evolutionary legacy of populations that once spawned above Oroville Dam. The FRFH population is included in the ESU based on its genetic linkage to the natural spawning population and the potential for development of a conservation strategy (70 FR 37160; June 28, 2005).

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions (i.e., diversity groups) (Lindley et al. 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River), and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). The northwestern California diversity group has two low abundance persisting populations of spring-run in Clear and Beegum creeks. In the San Joaquin River basin, the southern Sierra Nevada diversity group, observations in the last decade suggest that spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2015).

The CV spring-run Chinook salmon ESU is comprised of two known genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised by introgression with the fall-run ESU (Good et al. 2005, Garza et al. 2008, Cavallo et al. 2011).

Because the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, NMFS can evaluate risk of extinction based on VSP in these watersheds. Over the long term, these three remaining populations are considered to be vulnerable to anthropomorphic and naturally occurring catastrophic events. The viability assessment of CV spring-run Chinook salmon, conducted during NMFS' 2010 status review (NMFS 2011), found that the biological status of the ESU had worsened since the last status review (2005), and the status review recommends that the species status be reassessed in 2 to 3 years as opposed to waiting another 5 years if the decreasing trend continued. In 2012 and 2013, most tributary populations increased in returning adults, averaging more than 13,000. However, 2014 returns were lower again—approximately 5,000 fish—indicating the ESU remains highly fluctuating. The most recent status review was conducted in 2015 (NMFS 2016), and it looked at promising increasing populations in 2012 to 2014; however, the 2015 returning fish were extremely low (1,195), with additional pre-spawn mortality reaching record lows. Returns in 2016 were slightly better but still low (6,453), signifying a continuation of the instability of the population and reason for concern (CDFW 2017). Since the effects of the 2012 to 2015 drought have not been fully realized, NMFS anticipates at least several more years of very low returns, which may result in severe rates of decline (NMFS 2016).

Spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson et al. 2011). CV spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and they would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002, 2003, and 2015, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser et al. 2013).

In summary, the extinction risk for the CV spring-run Chinook salmon ESU was evaluated for years 2012 – 2014, which remained at moderate risk of extinction (NMFS 2016). However, based on the severity of the drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (NMFS 2016).

2.2.3 California Central Valley Steelhead DPS

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Current abundance data for CCV steelhead are limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data are the most reliable because redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

CCV steelhead returns to CNFH increased from 2011 to 2014. After reaching a low of only 790 fish in 2010, 2013 and 2014 have averaged 2,895 fish. Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200 to 300 fish each year. Numbers of wild adults returning each year ranged from 252 to 610 from 2010 to 2014, respectively.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 143 redds have been counted on the American River from 2002 to 2015 (data from Hannon et al. 2003, Hannon and Deason 2008, Chase 2010). An average of 178 redds have been counted in Clear Creek from 2001 to 2015 following the removal of Saeltzer Dam, which allowed steelhead access to additional spawning habitat. The Clear Creek redd counts range from 100 to 1,023 and indicates an upward trend in abundance since 2006 (U.S. Fish and Wildlife Service 2015).

The returns of CCV steelhead to the FRFH experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively. In recent years, however, returns have experienced an increase, with 830, 1,797, and 1,505 fish returning in 2012, 2013, and 2014, respectively. Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present.

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the FWS Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Trawl data indicate that the level of natural production of steelhead has remained very low since the 2011 status review, suggesting a decline in natural production based on consistent hatchery releases. Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the production of wild steelhead relative to hatchery steelhead (CDFW 2017). The overall catch of steelhead has declined dramatically since the early 2000s, with an overall average of 2,705 in the last 10 years. The percentage of wild (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999.

About 80 percent of the historical spawning and rearing habitat once used by CCV steelhead in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005, NMFS 2016). Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adults intercepted at the CNFH weir), the American River, Feather River, and Mokelumne River.

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

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

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (NMFS 2016); the long-term trend remains negative. Hatchery production and returns are dominant. Most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. In summary, the status of the CCV steelhead DPS appears to have remained unchanged since the 2011 status review, and the DPS is likely to become endangered within the near future throughout all or a significant portion of its range (NMFS 2016).

2.2.4 California Central Valley Steelhead Designated Critical Habitat

The critical habitat designation for CCV steelhead (70 FR 52488; September 2, 2005) lists freshwater spawning sites; freshwater rearing sites; freshwater migration corridors; and estuarine areas as the PBFs. The geographical extent of designated critical habitat includes the Sacramento, Feather, and Yuba rivers and the Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River above the Merced River confluence; and the waterways of the Delta.

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

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

2.2.5 Southern DPS of North American Green Sturgeon

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During late summer and early fall, subadults and non-spawning adult green sturgeon can frequently be found aggregating in estuaries along the Pacific coast (Emmett et al. 1991, Moser and Lindley 2006). Using polyploid microsatellite data, Israel et al. (2009) found that green sturgeon within the Central Valley of California belong to the Southern DPS. Additionally, acoustic tagging studies have found that green sturgeon found spawning within the Sacramento River are exclusively Southern DPS green sturgeon (Lindley *et al.* 2011). In waters inland from the Golden Gate Bridge in California, Southern DPS green sturgeon are known to range through the estuary and the Delta and up the Sacramento, Feather, and Yuba rivers (Israel et al. 2009, Cramer Fish Sciences 2011, Seeholtz et al. 2014). It is unlikely that green sturgeon utilize areas of the San Joaquin River upriver of the Delta with regularity, and spawning events are thought to be limited to the upper Sacramento River and its tributaries. There is no known modern usage of the upper San Joaquin River by green sturgeon, and adult spawning has not been documented there (Jackson and Eenennaam 2013).

Recent research indicates that the Southern DPS is composed of a single, independent population, which principally spawns in the mainstem Sacramento River and also breeds opportunistically in the Feather River and possibly the Yuba River (Cramer Fish Sciences 2011, Seeholtz et al. 2014). Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. Whether Southern DPS green sturgeon display diverse phenotypic traits, such as ocean behavior, age at maturity, and fecundity, or if there is sufficient diversity to buffer against long-term extinction risk is not well understood. It is likely that the diversity of Southern DPS green sturgeon is low, given recent abundance estimates (NMFS 2015).

Trends in abundance of Southern DPS green sturgeon have been estimated from two long-term data sources: (1) salvage numbers at the state and Federal pumping facilities (CDFW 2017), and (2) by incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program (Dubois and Harris 2015, 2016). Historical estimates from these sources are likely unreliable because the Southern DPS was likely not taken into account in incidental catch data, and salvage does not capture rangewide abundance in all water year types. A decrease in Southern DPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities, the Skinner Delta Fish Protection Facility (SDFPF), and the Tracy Fish Collection Facility (TFCF). These data should be interpreted with some caution. Operations and practices at the facilities have changed over the project lifetime, which may affect salvage data. These data likely indicate a high production year versus a low production year qualitatively, but cannot be used to rigorously quantify abundance.

Since 2010, more robust estimates of Southern DPS green sturgeon have been generated. As part of a doctoral thesis at the University of California at Davis (UC Davis), Ethan Mora has been using acoustic telemetry to locate green sturgeon in the Sacramento River and to derive an adult spawner abundance estimate (Mora et al. 2015). Preliminary results of these surveys estimate an average annual spawning run of 223 (using DIDSON cameras) and 236 (using telemetered fish). This estimate does not include the number of spawning adults in the lower Feather or Yuba rivers, where green sturgeon spawning was recently confirmed (Seesholtz et al. 2014).

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

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

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

2.2.6 Southern DPS of North American Green Sturgeon Designated Critical Habitat

The critical habitat designation for Southern DPS green sturgeon (74 FR 52300; October 9, 2009) lists the PBFs for both freshwater riverine systems and estuarine habitats as: food resources, water flow, water quality, migratory corridor, depth, and sediment quality. Additionally, substrate type or size is also a PBF for freshwater riverine systems. In addition, the PBFs include migratory corridor, water quality, and food resources in nearshore coastal marine areas.

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

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area includes the southern Sacramento-San Joaquin Delta and generally comprises the lands and waterways of the Delta southwest of the City of Stockton. Major waterways within the south Delta include the San Joaquin River, Old River, Middle River, Woodward and North Victoria canals, Grant Line and

Fabian canals, Italian Slough, Tom Paine Slough and the adjoining canals of the CVP and SWP. In addition, the action area not only encompasses the lands and waterways described above, but also includes the lands and waterways of the central Delta, including the lower San Joaquin River downstream of Old River, Columbia Cut and Turner Cut, and all reaches of Middle River and Old River as well as any adjoining sloughs and canals that are hydrologically connected to the channels described above.

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 <u>Status of the Species in the Action Area</u>

The action area functions primarily as a migratory corridor for adult and juvenile CCV steelhead. All adult CCV steelhead originating in the San Joaquin River watershed will have to migrate through the action area in order to reach their spawning grounds and to return to the ocean following spawning. Likewise, all CCV steelhead smolts originating in the San Joaquin River watershed will also have to pass through the action area during their emigration to the ocean. The waterways in the action area also are expected to provide some rearing benefit to emigrating steelhead smolts as they move through the action area. The action area also provides some use as a migratory corridor and rearing habitat for juvenile Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon that are drawn into the south Delta by the actions of the CVP and SWP water diversion facilities. The action area also functions as migratory, holding and rearing habitat for adult and juvenile Southern DPS of North American green sturgeon.

2.4.1.1 Sacramento River Winter-run Chinook Salmon ESU

The temporal occurrence of Sacramento River winter-run Chinook salmon smolts and juveniles in the action area are best described by the salvage records of the CVP and SWP fish handling facilities. Based on salvage records covering the last 10 years at the CVP and SWP, Sacramento River winter-run Chinook salmon are typically present in the south Delta action area starting in December. Their presence peaks in March and then rapidly declines from April through June. Nearly 50 percent of the average annual salvage of Sacramento River winter-run Chinook salmon juveniles occurs in March (50.4 percent). Salvage in April accounts for only 2.8 percent of the average annual salvage and falls to less than 1 percent for May and June combined. The presence of juvenile Sacramento River winter-run Chinook salmon in the south Delta is a function of river flows on the Sacramento River, where the fish are spawned, and the demands for water diverted by the SWP and CVP facilities. When conditions on the Sacramento River are conducive to stimulating outmigrations of juvenile Sacramento River winter-run Chinook salmon, the draw of the CVP and SWP pumping facilities pulls a portion of these emigrating fish through the waterways of the central and southern Delta from one of the four access points originating on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough). The combination of pumping rates and tidal flows moves these fish towards the southwestern corner of the Delta and into the action area. When the combination of pumping rates and fish movements are high, significant numbers of juvenile Sacramento River winter-run Chinook salmon are drawn into the south Delta.

2.4.1.2 Central Valley Spring-run Chinook Salmon ESU

Like Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in the action area is influenced by CVP and SWP water diversions and the flows on the Sacramento River and its tributary watersheds. Currently, all known populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed.

Juvenile CV spring-run Chinook salmon first begin to appear in the action area in January. A significant presence of fish does not occur until March (17.2 percent of average annual salvage) and peaks in April (65.9 percent of average annual salvage). By May, the salvage of CV spring-run Chinook salmon juveniles declines sharply (15.5 percent of average annual salvage) and essentially ends by the end of June (1.2 percent of average annual salvage).

2.4.1.3 California Central Valley Steelhead DPS

CCV steelhead occur in both the Sacramento River and the San Joaquin River watersheds, although the spawning population of fish is much greater in the Sacramento River watershed (NMFS 2016). Like Sacramento River winter-run Chinook salmon, Sacramento River steelhead can be drawn into the south Delta by the actions of the CVP and SWP water diversion facilities. Small, remnant populations of CCV steelhead are also known to occur on the Stanislaus River and the Tuolumne River and their presence is assumed on the Merced River due to proximity, similar habitats, and historical presence. CCV steelhead smolts first start to appear in the action area in November based on the records from the CVP and SWP fish salvage facilities. Their presence increases through December and January (21.6 percent of average annual salvage) and peaks in February (37.0 percent) and March (31.1 percent) before rapidly declining in April (7.7 percent). By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP. Kodiak trawls conducted by the FWS and CDFW on the mainstem of the San Joaquin River just above the HOR during the Vernalis Adaptive Management Program (VAMP) experimental period routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin Basin. Monitoring is less frequent prior to the VAMP, therefore emigrating steelhead smolts have a lower probability of being detected. Rotary Screw Trap (RST) monitoring on the Stanislaus River at Caswell State Park and further upriver near the City of Oakdale indicate that smolt-sized fish start emigrating downriver in January and can continue through late May. Fry-sized fish (30 to 50 mm) are captured at the Oakdale RST starting as early as April and continuing through June. Adult escapement numbers have been monitored for the past several years with the installation of an Alaskan style weir on the lower Stanislaus River between Ripon and Riverbank. Typically, very few adult steelhead have been observed moving upstream past the weir due to the removal of the structure at the end of December. However, in 2006 to 2007, the weir was left in place through the winter and spring, and seven adult steelhead were counted moving upstream. In 2008-2009, 15 adult steelhead moved upstream past the weir. The weir counts indicate that at least some adult steelhead are moving upstream from the lower Stanislaus River into upstream areas. These fish, due to their migratory behavior, timing of entrance, and typically larger size would be considered potential steelhead returning to the tributary.

2.4.1.4 Southern DPS of North American Green Sturgeon

Juvenile green sturgeon from the Southern DPS are routinely collected at the SWP and CVP salvage facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981 through 2007, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. The sizes of these fish are less than 1 meter and average 330 mm with a range of 136 mm to 774 mm. The size range indicates that these are sub-adult fish rather than adult or larval/juvenile fish. Recent telemetry data and sturgeon acoustic tracking, as reported by Thomas et al. (2013), indicate that these sub-adult fish utilize the Delta for rearing for a period of up to approximately 3 years. The proximity of the CVP and SWP facilities to the action area would indicate that sub-adult green sturgeon have a strong potential to be present within the action area during the construction and operation of the temporary barriers, but that their population density would be low in these waters.

2.4.2 Status of Designated Critical Habitats in the Action Area

The action area is within the San Joaquin Delta hydrologic unit ([HU] 18040003) and is included in the critical habitat designated for CCV steelhead. The San Joaquin Delta HU is in the southwestern portion of CCV steelhead range and includes portions of the south and central Delta channel complex. The San Joaquin Delta HU encompasses approximately 628 square miles, with 455 miles of stream channels (at 1:100,000 hydrography). The critical habitat analytical review team identified approximately 276 miles of occupied riverine/estuarine habitat in this hydrologic subunit area, and that it contained one or more PBFs for CCV steelhead (NMFS 2005). The PBFs of steelhead critical habitat within the action area include freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The features of the PBFs included in these different sites essential to the conservation of the CCV steelhead DPS include the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrients sources, natural cover and shelter, migration routes free from obstructions, no excessive predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater rearing and migration by CCV steelhead juveniles and smolts and for adult freshwater migration. No spawning of CCV steelhead occurs within the action area.

In regards to the designated critical habitat for the Southern DPS of green sturgeon, the action area includes the following PBFs: adequate food resources for all life stages utilizing the Delta; water flows sufficient to allow adults, subadults, and juveniles to orient to flows for migration and normal behavioral responses; water quality sufficient to allow normal physiological and behavioral responses; unobstructed migratory corridors for all life stages utilizing the Delta; a broad spectrum of water depths to satisfy the needs of the different life stages present in the estuary; and sediment with sufficiently low contaminant burdens to allow for normal physiological and behavioral responses to the environment.

The general condition and function of this habitat has already been described in the *Status of the Species and Critical Habitat* section of this opinion. The substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. The channels of the south Delta have been heavily riprapped with coarse stone slope protection on artificial levee banks and these channels have been straightened to enhance water conveyance through the system. The extensive riprapping and levee construction has precluded natural river channel migrations and the formation of riffle pool configurations in the Delta's channels. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been cleared for farming. Little riparian vegetation remains in the south Delta, limited mainly to tules growing along the foot of artificial levee banks. Numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (i.e., Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, etc.). These artificial channels have disturbed the natural flow of water through the south Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment. Sections of the south Delta have been routinely dredged by DWR to provide adequate intake depth to these agricultural water diversions. Shallow water conditions created by the actions of the SWP enhance the probability of pump cavitation or loss of head on siphons.

Water flow through the south Delta is highly manipulated to serve human purposes. Rainfall and snowmelt is captured by reservoirs in the upper watersheds, from which its release is dictated primarily by downstream human needs. The SWP and CVP pumps draw water towards the southwest corner of the Delta which creates a net upstream flow of water towards their intake points. Fish, and the forage base they depend upon for food, represented by free floating phytoplankton and zooplankton, as well as larval, juvenile, and adult forms, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the south Delta, numerous discharges of treated wastewater from sanitation wastewater treatment plants (e.g., Cities of Tracy, Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways are emptied into the waters of the San Joaquin River and the channels of the south Delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (i.e., selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, etc.).

The installation of the temporary rock barriers has been an ongoing action since 1991. Installation of the fall HOR barrier has occurred intermittently since the early 1960s to enhance water quality downstream in the Port of Stockton and the deep water ship channel (DWSC). These barriers have altered the hydrology of the south Delta each time they have been installed by redirecting flows and increasing water elevation behind the barriers.

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

2.4.3 Factors Affecting the Species and Habitat in the Action Area

The action area encompasses a small portion of the area utilized by CCV steelhead and the Southern DPS of North American green sturgeon. Many of the range-wide factors affecting these two species are discussed in section 2.2 of this opinion, and are considered the same in the action area. This section will focus on the specific factors in the action area that are most relevant to the proposed TBP.

The magnitude and duration of peak flows during the winter and spring, which affects listed salmonids in the action area, are reduced by water impoundment in upstream reservoirs. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks to avoid overwhelming the flood control structures downstream of the reservoirs (i.e., levees) and low lying terraces under cultivation (i.e., orchards and row crops) in the natural floodplain along the basin tributaries. Consequently, managed flows in the main stem of the river often truncate the peak of the flood hydrograph and extend the reservoir releases over a protracted period. These actions reduce or eliminate the scouring flows necessary to mobilize sediments and create natural riverine morphological features within the action area. Furthermore, the unimpeded river flow in the San Joaquin River basin is severely reduced by the combined storage capacity of the different reservoirs located throughout the basin's watershed. Very little of the natural hydrologic input to the basin is allowed to flow through the reservoirs to the valley floor sections of the tributaries leading to the Delta. Most is either stored or diverted for anthropogenic uses. Elevated flows on the valley floor are typically only seen in wet years or flood conditions, when the storage capacities of the numerous reservoirs are unable to contain all of the inflow from the watersheds above the reservoirs.

High water temperatures also limit habitat availability for listed salmonids in the San Joaquin River and the lower portions of the tributaries feeding into the main stem of the river. High summer water temperatures in the lower San Joaquin River frequently exceed 72ºF, and create a thermal barrier to the migration of adult and juvenile salmonids.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and shaded riverine aquatic cover. Such bank protection generally results in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the cumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (FWS 2000). Armored embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat. Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in large woody debris (LWD).

The use of rock armoring limits recruitment of LWD from non-riprapped areas, and greatly reduces, if not eliminates, the retention of LWD once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of LWD to become securely snagged and anchored by sediment. LWD tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place for extended periods to generate maximum values to fish and wildlife (FWS 2000). Recruitment of LWD is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (FWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining near shore refuge areas.

Point and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of, and within the action area. The effects of these impacts are discussed in section 2.2 of this biological opinion. Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates in fish. Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e., heavy metals) concentrations may deleteriously affect early life-stage survival of fish in the Central Valley watersheds (FWS 1995). Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, water quality, non-native invasive species, etc., are discussed in section 2.2 of this opinion.

2.5 Effects of the Action

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

2.5.1 Construction Impacts

A full description of the barrier installation, operational schedule, and removal was provided in Section 1.3 of this opinion. Based on the salvage data from the CVP and SWP facilities from 1999 to the present available on Reclamation's Central Valley Operations web site (http://www.usbr.gov/mp/cvo/), NMFS expects individual Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon to be present in the south Delta during the proposed spring construction periods. NMFS estimates that approximately 50 percent of the annual Sacramento River winter-run Chinook salmon emigrants that are collected at the CVP and SWP facilities are collected during the month of March. Likewise, the salvage data from the past several years indicate that approximately 17 percent of the annual Central Valley spring-run Chinook salmon outmigration through the Delta occurs during the month of March, as represented by the salvage data at the CVP and SWP fish collection facilities. Therefore, even though these two Chinook salmon runs do not originate in the San Joaquin River watershed, their presence at the SWP and CVP fish salvage facilities in the southwest corner of the Delta indicates that they are likely to be present in the western waterways of the south Delta during the TBP construction actions. The same data indicate that approximately 31 percent of the total annual CCV steelhead smolt outmigration takes place during the month of March and thus also faces exposure to the barrier installation activities. It is unclear exactly what proportion of the total CCV steelhead smolt outmigration includes those smolts emigrating from the San Joaquin River watershed. Those smolts that do emigrate from the San Joaquin River watershed during the month of March (or later) time frame are likely to face at least one of the barriers during their migration through the Delta. Finally, low numbers of juvenile and sub adult green sturgeon from the Southern DPS are collected at the CVP and SWP fish collection facilities throughout the year, including the month of March. Much is unknown about how these young green sturgeon utilize the channels of the south Delta, including their distribution and range, their behavior, and their density. However, like the different salmonids, their presence at the fish collecting facilities indicates that they are present in the south western corner of the Delta and can be expected to occur in any of the adjoining waterways feeding into the region adjacent to the CVP and SWP intakes, including Old River, MR, GLC and Fabian – Bell Canal.

The construction of the rock barriers for the TBP requires the placement of rock and gravel into the channels of the south Delta during a time period when outmigrating CCV steelhead smolts are present in the San Joaquin River mainstem. Furthermore, due to the physical proximity of the three agricultural barriers (ORT, MR, GLC) to the intakes of the CVP and SWP, when juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead and the Southern DPS of North American green sturgeon are present at the CVP/SWP diversions during the construction period, then these fish are presumed to be present in the waterways containing these three barriers as well. The placement of rock below the waterline will cause noise and physical disturbance that could displace juvenile and adult fish into adjacent habitats, or crush and injure or kill individuals. The impact of rock being placed in the river disrupts the river flow by producing surface water waves disturbing the water column; resulting in increased turbulence and turbidity. Migrating juveniles react to this disturbance by a startle response in which they are likely to suddenly disperse in random directions (Carlson et al. 2001). This displacement can lead them into predator habitat where they can be targeted, and injured or killed by opportunistic predators taking advantage of juvenile behavioral changes. Carlson et al. (2001) observed this behavior occurring in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators.

The construction of the rock barriers also is expected to generate underwater noise from both terrestrial and underwater sources, occasionally reaching intense levels. Heavy earthmoving equipment will be utilized on the banks of the rivers and levees to move the piles of rock and gravel needed for the construction of the barriers. These activities will generate sharp transient noises from metal components (buckets, scoops, etc.) striking rock that will propagate into the water column as coupled noise traveling through the underlying substrate. The process of dumping the rocky material into the water from front loaders, excavators, and dump trucks is expected to generate intense noise from the rocks striking each other as they fall and tumble into their final position. The effects resulting from the generation of intense sound within the water column can be extrapolated from reports on dredging and pile driving. Feist et al. (1992) found that noise from pile driving activities in Puget Sound affected the general behavior of juvenile salmon by temporarily displacing them from the active construction areas. Nearly twice as many fish were observed at construction sites on non-pile driving days compared to days when pile driving occurred. However, on the waterways of the San Joaquin River and the south Delta, the channel widths (<100m) may not allow complete avoidance of the construction disturbances. Burgess and Blackwell (2003) indicated that vibratory installation of a sheet pile wall in an upland position generated sound levels of approximately 140 dB (re: 1 µpascal [1µPa]) in the adjacent waterway at a distance of 200 feet, indicating that the noise was transmitted through the soil to the water column. Based on the acoustic monitoring results generated from the installation of last year's TBP, the level of noise generated during construction activities is not expected to reach levels that will incur tissue injury (> 207 decibels peak, referenced to 1µPa), but is likely to create behavioral alterations [>150 decibels root mean square (dBrms), re: 1µPa] to fish within 100 meters of the source of the acoustic signal. The duration of the rock placement activity is not expected to occur for more than 24 days at any given location, unless culvert repairs or replacement are required in which case 10 additional days may become necessary. Placement of the rock occurs only during daylight hours, and the repetitive frequency of the rocks being dumped is measured on the order of half a minute (excavator) to several minutes (dump trucks and front loaders). This reduces the risk of accumulated sound levels as experienced during pile driving activities that have a repetitive frequency measured on the order of a few seconds between strikes.

The placement of the large volumes of rock and gravel necessary to construct the barriers into the channels of the south Delta places migrating fish at risk of being crushed or injured by the falling rock. NMFS believes that due to the process of closing off the channel with the rock barriers, all sizes of fish (ranging from approximately 80 mm Chinook salmon smolts to 250 mm steelhead smolts) are at some risk of exposure to the construction activity. Typically, smaller fry-sized fish would have the highest risk potential due to their near shore orientation and slower swimming speeds, but this size class of fish is unlikely to be present in the construction area due to the season and the location downstream of the natal reaches of steelhead and Chinook salmon. However, since the barriers progressively close across the width of the channel as they are being constructed, even those larger smolt-sized fish migrating through the center of the channel, would at some point be vulnerable to the rock placement process as they try to move through the construction area under the influence of the river's flow. NMFS believes that most migrating fish will pass through the barrier construction zones when terrestrial activity is low or absent, particularly as the barrier nears completion and the depth of the water across the top of the barrier crest becomes shallower. NMFS further believes that passage over the crest is more likely to occur under low light conditions, when construction activity should not be occurring. However, individual fish could decide to cross the alignment of the barrier at any time and thus face a higher level of risk.

Rock placement and positioning of associated structures, such as the barrier culverts, will disturb local soils and the underlying riverbed, resulting in increased erosion, siltation, and sedimentation. Highly elevated suspended sediments can adversely affect salmonids in the area by clogging sensitive gill structures (Nightingale and Simenstad 2001), but these effects are generally confined to turbidity levels in excess of 4,000 mg/L. Based on the best available information, including measured turbidity increases during the construction of the TBP in previous years, NMFS does not anticipate that turbidity levels associated with the TBP will reach these deleterious levels. During the construction of the barriers in previous years, measurements of turbidity 100 meters downstream from the construction activity rarely exceeded 15 Nephelometric Turbidity Units (NTUs), and even then those observed exceedances were never in succession indicating they were always short in duration and small in scale when they have occurred. However, responses of salmonids to elevated levels of suspended sediments often fall into three major categories: physiological effects, behavioral effects, and habitat effects (Bash *et al.* 2001). The severity of the effect is a function of concentration and duration (Newcombe and MacDonald 1991, Newcombe and Jensen 1996) so that low concentrations and long exposure periods are frequently as deleterious as short exposures to high concentrations of suspended sediments. A review by Lloyd (1987) indicated that several behavioral characteristics of salmonids can be altered by even relatively small changes in turbidity (10 to 50 NTUs). Salmonids exposed to slight to moderate increases in turbidity exhibited avoidance, loss of station in the stream, reduced feeding rates and reduced use of overhead cover. Short-term increases in turbidity and suspended sediment may disrupt feeding activities of fish or result in temporary displacement from preferred habitats. Numerous studies show that suspended sediment and turbidity levels moderately elevated above natural background values can result in non-lethal detrimental effects to salmonids. Suspended sediment affects salmonids by decreasing reproductive success, reducing feeding success and growth, causing avoidance of rearing habitats, and disrupting migration cues (Bash et al. 2001). Sigler et al. (1984 in Bjornn and Reiser 1991) found that prolonged turbidity between 25 and 50 NTUs reduced growth of juvenile coho salmon and steelhead. MacDonald *et al.* (1991) found that the ability of salmon to find and capture food is impaired at turbidities from 25 to 70 NTUs. Reaction distances of rainbow trout to prey were reduced with increases of turbidity of only 15 NTUs over an ambient level of 4 to 6 NTUs in experimental stream channels (Barret et al. 1992). Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Increased turbidity, used as an indicator of increased suspended sediments, also is correlated with a decline in primary productivity, a decline in the abundance of periphyton, and reductions in the abundance and diversity of invertebrate fauna in the affected area (Lloyd 1987, Newcombe and MacDonald 1991). Increased sediment delivery can also fill interstitial substrate spaces and reduce cover for juvenile fish (Platts et al. 1979) and abundance and availability of aquatic invertebrates for food (Bjornn and Reiser 1991). NMFS expects turbidity to affect Chinook salmon and steelhead in much the same way that it affects the other salmonids used in these studies, because of similar physiological and life history requirements between species.

The disturbance of the channel banks and bottom at each of the barrier installation sites during barrier construction activities will increase suspended sediments locally, which will produce turbidity plumes that will extend down current from the construction activity (all four barrier locations are under tidal influence to some degree and, therefore, have bidirectional water flow through the action area twice a day). The duration of turbidity plumes resulting from in-water construction related activities is expected to last as long as those activities continue, returning to background conditions within several hours after work has ceased. Following the proposed schedules for barrier installation, in-water work activities will vary between sites, but the longest construction is anticipated to last 24 days at any of the sites, with the possible addition of 10 further days should culvert repairs or replacement become necessary. In recognition of the fact that the agricultural barriers are constructed concurrently, this corresponds to a maximum of approximately 1 month of potential continuous exposure to construction-related effects resulting from the installation of the TBP each year. Although Chinook salmon and steelhead are highly migratory and capable of moving freely throughout the action area, a substantial increase in turbidity may injure fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Disrupting these behaviors increases the likelihood that individual fish will face increased competition for food and space, and experience reduced growth rates or possibly weight loss resulting in harm to individuals and increased risk to the affected species. TBP-related turbidity increases may also affect the sheltering abilities of some fish and may decrease their likelihood of survival by increasing their susceptibility to predation. Conversely, some turbidity is helpful in reducing predation by shielding the fish from visual predators in a turbid field (Gregory and Levings 1998).

Resuspension of contaminated sediments is expected to have negative effects upon salmonids or green sturgeon that encounter the sediment plume, even at low turbidity levels. Lipophilic compounds in the fine organic sediment, such as toxic PAHs, can be preferentially absorbed through the lipid membranes of the gill tissue, providing an avenue of exposure to salmonids or green sturgeon within the sediment plume (Newcombe and Jensen 1996). Similarly, charged particles such as metals (e.g., copper), may interfere with ion exchange channels on sensitive membrane structures like gills or olfactory rosettes and increases in ammonia from the sediment may create acutely toxic conditions for salmonids or green sturgeon present in the channel margins.

Based on similar projects conducted by DWR and the Corps (i.e., levee repair work and placement of rock riprap), construction activities are expected to result in periodic increases in localized turbidity levels ranging from 25 to 75 NTUs. These levels are capable of affecting normal feeding and sheltering behavior. Although levee protection work on the Sacramento River produced turbidity plumes that hugged the shoreline for several hundred feet downstream of the rock placement action, work on the TBP is expected to produce plumes that are more dispersed across the river channel. The river channels in the south Delta are narrower than the Sacramento River channel or its associated tributaries and have a strong tidal signal in the action area. The tidal signal causes the flow in the river channel to reverse itself twice a day, thus moving the sediment plume upstream and downstream on each tidal cycle with some degree of overlap. Furthermore, the barriers span the entire channel and are not just restricted to the channel edges. This allows sediment plumes to be present across the entire width of the channel at some point in the construction cycle. Eventually the gap between the two leading edges of the barrier is sufficiently narrow that the sediment plume will cover the entire width of the open channel in the construction zone. Once construction stops, water quality is expected to return to background levels within a few hours to days, depending on how high the percentage of fines were in the stockpiled barrier material. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales, and straw wattles will minimize the amount of TBP-related sediment originating from the upland areas of the TBP and will minimize the potential for post-construction turbidity changes should precipitation events occur after the barrier construction. NMFS expects that most fish will actively avoid the elevated turbidity plumes if possible. For those fish that do not or cannot avoid the turbid water, exposure is expected to be brief (i.e., minutes to hours) and not likely to cause injury or death from reduced growth, or physiological stress. This expectation is based on the general avoidance behaviors of salmon and the requirement to suspend construction when turbidity exceeds Regional Board standards. However, some juveniles that are exposed to turbidity plumes may be injured or killed by predatory fish that take advantage of disrupted normal behavior. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume.

Based on the salvage data gathered for the CVP/SWP, roughly 50 percent of the annual winter-run Chinook salmon salvage occurs during the month of March, when NMFS anticipates they are likely to be exposed to construction related effects associated with the installation of the temporary barriers. This is likely to be an overestimate since not all winter-run smolts in the south Delta will encounter the barriers in close enough proximity to be subjected to turbidity plumes, acoustic disturbances, or other construction related effects.

According to the CVP/SWP salvage data, Central Valley spring-run Chinook salmon smolts primarily enter the south Delta during the month of April (66 percent of average annual salvage totals). Using the same rationale as was used for the winter-run sized Chinook salmon smolts, NMFS estimates that roughly 17 percent of the annual south Delta spring-run sized Chinook salmon salvage numbers will be present in the south Delta during the month of March when installation of the barriers is likely to be occurring, and thus have the potential to encounter construction-related effects resulting from those activities.

The CVP/SWP salvage records indicate that approximately 31 percent of the annual CCV steelhead salvage occurs during the month of March. NMFS predicts that these fish will have the potential to be exposed to construction-related effects in conjunction with the installation of the barriers. However, NMFS also realizes that a much greater proportion of San Joaquin River basin steelhead will be exposed to the turbidity plumes than those originating from the Sacramento River basin due to their comparative proximity to the action area and routes of migration through the south Delta. Estimates vary, but approximately 50 percent of the water flows in the main stem San Joaquin River above the HOR are diverted into the Old River channel under normal conditions. If emigrating steelhead smolts are moving past the HOR during construction, archival data from numerous studies, including the VAMP studies, indicate that approximately half of them should follow the flow split and move down the Old River channel. These fish would then have to pass at least 2 barriers to exit the south Delta; the HOR and one of the three agricultural barriers depending on their route selection.

2.5.2 Hydrodynamics of Barrier Operations

2.5.2.1 Farfield Effects

Installation of the three agricultural barriers creates alterations in the circulation of water in the south Delta. The barriers create a delay in the tidal signal between the channels upstream of the barriers and the downstream sections of the channels below the barriers. The barriers also create differences in water elevations between the upstream segments above the barriers and those segments below the barriers. In addition to the increases in water elevations, alterations in the net flows and their direction within the channels of the south Delta occur with the installation of the temporary barriers. DWR has modeled these flows using its Delta Simulation Model (DSM2-Hydro). In general, the average net flows in the south Delta channels are reduced or reversed when the barriers are in place. Prior to barrier installation, net flows in Old River and Grantline/Fabian and Bell Canal are downstream and directly influenced by flows entering the Old River channel from the mainstem San Joaquin River at HOR as well as pumping rates at the CVP and SWP facilities. Flows in MR are harder to predict. When flows in the mainstem San Joaquin River at Vernalis are high, then flows entering the south Delta channels are higher and Middle River tends to have a net positive flow downstream along its entire length. Conversely, when San Joaquin River flows are low, then the net flow in lower MR tends to be negative and the flows entering from Old River near Undine Road are "balanced" by this inflow of water from downstream. Once the ORT, MR and HOR barriers are installed ("normal" VAMP barrier conditions), the net flows above the ORT and MR barriers generally become negative and flow proceeds in an upstream direction. Flows in GLC remain positive and net flows proceed in a downstream direction towards the CVP and SWP water intakes. Once the spring HOR barrier is removed at the end of the VAMP experiment (or sometimes later), net positive flows resume in the upper portion of Old River and flow enters both the lower Old River channel and Middle River channel below their split. Flows from upstream may become "balanced" by net negative flows originating from downstream creating areas of null flows in the interior sections of the channels. This condition is more pronounced as the demand for irrigation water increases within the interior of the south Delta and inflow from the San Joaquin River is low (i.e., flows below approximately 2,000 cfs). The flow patterns in the interior of the south Delta under these parameters creates a "hydraulic trap" for particles (or fish) moving with the river's flow. These alterations in the flow patterns in the south Delta reduce the ability of emigrating salmonids, particularly CCV steelhead from the San Joaquin River basin, to successfully travel through the region towards the western edge of the Delta. These changes will create a confusing flow signal for any emigrating fish within the affected areas, diminishing the fish's ability to find a clear route towards the ocean. Increases in travel time through the south Delta channels are expected to expose fish to higher levels of predation, raise the risk of entrainment into any one of the thousands of small agricultural water diversions found in the area, and prolong the time that fish are exposed to reaches with degraded water quality.

During the period when all of the barriers are installed in the south Delta, the hydrodynamics of the Delta interior to the north are also affected. Under the influence of pumping at the CVP and SWP, water is drawn southwards from the lower San Joaquin River near McDonald, Mandeville and Medford Islands down the channels of Old River, MR, Columbia Cut, and Turner Cut. This creates net negative flows in these channels and water moves upstream towards the CVP and

SWP diversion points in the south Delta. Any fish that was successful in staying in the main channel of the San Joaquin River past the HOR still has the possibility of being drawn back into the south Delta through these aforementioned waterways under the influence of the pumping actions of the CVP and SWP and tidal oscillations (Vogel 2004). For fish that are drawn into these channels, the risk of predation, entrainment by agricultural diversions, and exposure to degraded water quality increases. These factors are expected to reduce their chances of survival.

The barriers also impact water quality parameters, although to varying degrees. Based on the data provided by the annual reports submitted by DWR, specific conductance is generally higher upstream of the barriers than below. Typically, Old River has the highest specific conductance while Middle River has the lowest. In 2005, this relationship did not hold, as flows from the San Joaquin River were much higher than in previous years, and the south Delta channels were all well flushed throughout the summer period. Dissolved oxygen and water temperature also appear to show a strong correlation with season as represented by ambient air temperature. As ambient air temperature increases, water temperature also increases, while DO levels decline. Barrier effects may contribute to the creation of DO sags around the barriers (ORT and GLC) and within the interior sections of the south Delta channels due to flow conditions (null zones), input of irrigation return water, input of waste waters from sanitation plants, nutrient loading, and excessive primary productivity depleting nighttime DO levels through respiration. These decreases in ambient water quality parameters would have negative impacts on the survival of any salmonid found in the affected waterways. Lower DO levels would lessen the swimming ability of migrating smolts and thus reduce the likelihood of successfully escaping predators better suited to low DO environmental conditions. Similarly, any green sturgeon that was caught in the interior of the south Delta during the installation of the barriers has the potential to be exposed to this lowered water quality until they find their way out of the south Delta or the barriers are removed in the fall.

2.5.2.2 Nearfield Effects

The three agricultural barriers will function as open channel weirs within the waterways of the south Delta. In general, water will flow over the crest of the three agricultural barriers and create a turbulent flow field downstream of the barriers. The characteristics of the flow field, however, will not remain static as water elevation and flow direction will change with the tidal cycle. Flow will typically be bi-directional, and water elevation will have both an ascending limb and descending limb, based on the point of the tidal cycle in which the observations are made.

The following is a generalization of the complex hydraulic environment created by the agricultural barriers within the channels of the south Delta. Concepts are based on information provided in the introductory reference text for open channel hydraulics by Chanson (2004). On an incoming tide, the water elevation downstream of the structures will be below the elevation of the weir crest (e.g., 1 foot above msl) and hence the upstream water surface elevation. The incoming tide will encounter the rock barrier and water surface levels will increase in elevation on the downstream side of the barrier. At the point of contact with the barrier, net water velocity will diminish to zero, since upstream flow is negated by the barrier. Flow from upstream of the barrier will continue to flow over the weir, creating a “riffle” over the downstream slope of the rock barrier before dissipating its energy in the “plunge pool” below the rock barrier. Depending on the differential in head between the upstream and downstream sides of the rock barrier, a significant hydraulic jump can be formed when energy in the faster velocity flow coming over the weir is dissipated by the downstream water mass in the plunge pool. It is expected that a complex circulation pattern will be set up by the formation of the hydraulic jump at the interface of the downstream water body and the flow of higher velocity water coming over the weir crest (and through the submerged culverts when they are tied open). The tongue of water flowing over the weir (the weirs are less than the width of their respective channels) will create counter circulating flow cells below the water surface and to either side of the main flow line. NMFS expects these circulation patterns to concentrate fish, such as listed salmonids, immediately downstream of the barrier structures. In addition to the downstream conditions described, flow over the top of the weir is likely to create a hydraulic "cushion" on the upstream side of the rock barriers below the elevation of the weir crest. NMFS expects that these areas of reduced velocity will also serve to concentrate fish prior to their passage over the top of the weir. In addition, these areas of reduced flow velocities serve as ambush points for predatory fish to prey on the concentrated schools of smaller fish in front of the barrier. These hydraulic conditions are expected to negatively affect listed salmonids traveling through the reaches occupied by the agricultural barriers.

In addition to flow over the top of the barrier's weir, additional flow from upstream can pass downstream through the submerged culverts during the early portion of the barrier's installation season. During this early stage of the barrier season, the agricultural barriers have their culverts tied open to allow tidal flow to pass through them. Normally, the tidal flap gates would close and prevent the ebb tide from flowing through the culverts in the downstream direction. As the tide reaches full flood and its elevation matches the water level upstream of the barriers, water is expected to move upstream through both the submerged culverts, and across the top of weir. In order for water movement to pass upstream through the 48-inch diameter culverts, the elevation head has to be higher on the downstream side than the upstream side of the barrier. This only occurs when the downstream surface elevations are above the height of the weir crest and the surface elevations upstream of the barriers. NMFS expects that fish below the weir will move with the upstream flow, passing through both the culverts and across the top of the barrier's weir with the incoming tide. Similar to the circulation conditions already described for water flowing downstream over the weir crests, NMFS expects water flowing upstream over the weirs during the flood stage of the tide to exhibit turbulent characteristics. Fish passing through this turbulent tongue of water will experience disorientation and become more susceptible to predation.

In summary, NMFS anticipates that the installation of the rock barriers will create hydraulic conditions that will impede free passage of fish through the channels of the south Delta. Water flow through the channels will be redirected, and the residency time of fish passing through the channels of the south Delta will be increased due to the changes in flow patterns. Furthermore, after passing through the San Joaquin River reach adjacent to the Port of Stockton and lower Roberts Island, a proportion of the fish in the main stem San Joaquin River will subsequently be entrained into the channels leading southwards under the influence of the CVP/SWP water diversion pumps. In addition, the barriers will create nearfield hydraulic conditions that will subject migrating fish to increased turbulence and disorientation than is normal for an unobstructed channel. The barriers will also create obstructions that will concentrate fish into confined areas of the channel prior to passing through the reach with the barrier structure. These effects will increase their risk of predation by larger fish such as striped bass and largemouth bass, as discussed in the next section.

2.5.3 Predation Risks Associated with the Barriers

Predatory fish are known to congregate below manmade barriers in rivers to feed on prey species passing through the barrier system. Studies of striped bass predation exist for several different salmonid populations. Blackwell and Juanes (1998) documented increased predation on juvenile Atlantic salmon smolts (*Salmo salar*) by striped bass passing over Essex Dam (a low head dam) on the Merrimack River in Massachusetts. Examinations of stomach contents from the striped bass captured below the dam indicated a high rate of predation on Atlantic salmon smolts during their downstream emigration to the Atlantic Ocean. Salmon smolts accounted for nearly 49 percent of the recovered prey species from striped bass that had stomachs containing prey, and composed nearly 80 percent of the total mass of prey remains recovered from those fish. The average size of the ingested smolts was approximately 150 mm and ranged from about 90 mm to 190 mm. Striped bass that had consumed smolts ranged in size from 38 to 69 cm in length. A similar level of predation by striped bass on fall-run Chinook salmon was observed by Merz (no date) on the Mokelumne River below the Woodbridge Irrigation Dam. In this study, striped bass were caught by electrofishing and angling and their stomach contents examined. A high concentration of striped bass were found immediately below the dam during the spring outmigration of fall-run Chinook salmon, and Merz estimated that approximately 11 to 28 percent of the fall-run Chinook salmon smolts passing the dam were consumed by the striped bass congregating below the structure. This value rose to almost 50 percent when unidentified, but suspected Chinook salmon smolt, remains were included in the analysis. In Coos Bay, Oregon, the decline of fall-run Chinook salmon coincided with large increases in the local striped bass populations and reductions in salmon spawning habitat. Subsequent reductions in the striped bass populations and improvements in the salmon spawning habitats coincided with a salmon population recovery (Johnson et al. 1992). Therefore, the presence of striped bass, in combination with the physical structures of the four barriers, is expected to increase the predation rate of salmonid smolts in the south Delta system during their outmigration.

Delta sport fisherman routinely target large striped bass in the eastern Delta’s lower Mokelumne River system when steelhead smolt releases are being made by the Mokelumne River Fish Hatchery. Fishermen typically are most successful when using artificial lures that resemble rainbow trout. Walters et al. (1997) confirmed that striped bass in the Colorado River below Hoover Dam were a factor in the poor return of small stocked rainbow trout in creel surveys. Fish less than 250 mm were found to be susceptible to striped bass predation in the Hoover Dam tailwaters. This is an equivalent size to the CCV steelhead smolts entering the Delta waterways from upstream tributaries. Consequently, striped bass are expected to contribute significantly to the predation of steelhead smolts migrating through the south Delta action area.

In both 2006 and 2007, Chinook salmon smolts were tagged with acoustical transmitters as part of the VAMP experiments on the San Joaquin River (San Joaquin River Group Authority 2006, 2007). In 2006, acoustic-tagged salmon smolts were released at Mossdale and Dos Reis in the lower San Joaquin River near HOR under high flow conditions that prevented the installation of a HOR barrier. Five acoustic receivers were placed at different locations in the south Delta to monitor for fish passage (Old River below the HOR barrier, Brandt Bridge over the lower San Joaquin River near the City of Lathrop, Turner Cut, Middle River near Bacon Island, and the San Joaquin River near Mandeville Island). The first release of 32 fish at Mossdale indicated that 25 fish (78 percent) went down the Old River channel. This was higher than expected based on the flow split (53 percent of flow went down Old River). Three of these 25 fish were detected later at Middle River near Bacon Island, but not at any of the receivers located farther downstream. Likewise, 5 of the 32 fish released were detected at the Brandt Bridge receiver location downstream of Mossdale, but not at the Turner Cut or San Joaquin River at Mandeville Island receivers. Two of the tagged fish released at Mossdale were never detected at the first two downstream monitoring stations and assumed to have been lost to predation within close proximity of the release point. The second release date split fish into a 35-fish group released at Mossdale and a 33-fish group at Dos Reis. The second Mossdale release indicated that only 40 percent of the released fish went down Old River when the flow split was 51 percent. Of these two groups, assumed predation ranged from 29 percent (Mossdale) to 58 percent (Dos Reis) within the river reaches to the first detectors (Old River at Head and Brandt Bridge). High levels of predation were observed just downstream of HOR where a deep scour hole occurs at a bend in the river. Actively feeding striped bass were observed, and 5 stationary tags were detected within the hole, assumed to have been defecated from predatory fish. An additional 8 tags were detected downstream of the river split adjacent to structures in the river (irrigation pump houses).

The 2006 data indicate that predation is a major factor in the loss of salmon smolts in the system. This general finding is supported by the 2007 data in which nearly 1,000 acoustically tagged fish were released. In 2007, a spring HOR barrier was installed, unlike 2006 when high flows prevented its installation. Fish were released from Durham Ferry (the normal upstream release point for VAMP studies), Mossdale, Dos Reis, Stockton, and below the HOR barrier on Old River. The number of detections declined significantly the farther the receivers were positioned downstream from the release points. A very high concentration of mortalities occurred adjacent to the Highway 4 Bridge over the San Joaquin River near Stockton, although the cause of this high incidence of mortality appears to have been related to water quality rather than predation. The declines in the number of detections at other receiver points indicate that attrition in the number of fish moving downstream is significant. Of those fish released below the HOR barrier on Old River, approximately 75 percent made it to the vicinity of the CVP and SWP intakes after the first release date. Only about 40 percent reached this point after the second release date. In the second series of releases, it appears that predatory fish keyed in on the tagged smolts as they moved through the south Delta channels below the HOR barrier. This may be correlated with a “learned response” by predators associating with the barriers and taking advantage of the hydraulics created by the barriers following the first release. NMFS staff (J. Stuart) has observed striped bass pushing schools of threadfin shad up against the barriers during the VAMP period prior to creating a “feeding frenzy” on the corralled fish. There also appears to be an elevated level of attrition between Durham Ferry and Mossdale (30 to 40 percent). Based on previous studies, NMFS infers that predation accounts for most of these losses.

A unique situation occurred in 2008 with the implementation of a court order to protect delta smelt in the lower reaches of the Middle and Old rivers preventing the installation of the spring HOR barrier. Holbrook et al. (2009) assessed the acoustic data from the 2008 study, and found that overall survival through the Delta from the release point at Durham Ferry to Chipps Island by all routes ranged from 0.05 ± 0.01 (SE) to 0.06 ± 0.01 between the first and second release groups. Survival was higher in the group of tagged fish that remained within the main stem of the San Joaquin River compared to those fish that travelled through the Old River pathway through the south Delta. Joint tag survival was 0.09 ± 0.02 for the fish that travelled in the San Joaquin River in both release groups, but only 22-33 percent (depending on release group) used this route. Only 4-10 percent of the tagged fish (depending on the release group) travelled through Turner Cut, but no tagged fish that used this route were detected exiting the Delta at Chipps Island. Most fish during this study (63-68 percent depending on the release group) moved into the Old River channel but overall fish-tag survival was 0.05 ± 0.01 percent, half of the survival rate for the main stem San Joaquin River route. The only fish that survived to Chipps Island using the Old River route were processed through the fish collection facilities of the CVP and SWP and released downstream after being transported by truck to the release sites. This suggested that salvage was the only successful migration route for fish that entered Old River. The proportion of fish that moved into the Old River channel was similar to the proportion of water from the San Joaquin River that entered the Old River channel, which averaged 63 percent, but varied tidally from 33 to 100 percent daily. This implies that fish are moving into the channel in relation to the flow split.

A complementary predator movement study was conducted in 2008 to coincide with the VAMP releases (Vogel 2010). Thirty adult and sub-adult striped bass were tagged with acoustic tags and released near the TFCF in the south Delta. The bass exhibited a strong tendency to remain in the south Delta region near their point of release. Of the 28 bass detected by receivers from the 30 released, 20 stayed in the vicinity of the trash racks at the TFCF for the month-long study. Some fish (6 individual tagged fish) moved between the TFCF and the SWP (Clifton Court Forebay) with one of these fish documented as entering and leaving the forebay during the study.

Although a rock barrier was not installed at the HOR in 2008, the three agricultural barriers were installed to benefit agricultural diverters in the south Delta. Under this arrangement, steelhead smolts from the San Joaquin River basin were able to enter the south Delta and were subjected to the full effects of the three agricultural barriers. NMFS anticipates that survival was lower under these conditions and that it negatively affected the CCV steelhead population in the San Joaquin Basin, based on the low survival rates seen for acoustically-tagged Chinook salmon in the Holbrook et al. (2009) study. Reduced survival of emigrating smolts through the south Delta will diminish the proportion of fish reaching the ocean and will be carried forward to reduce adult escapement numbers several years into the future. Reduced numbers of returning adults will reduce the viability of the San Joaquin River basin's steelhead population by reducing the potential number of progeny produced in the natal streams in subsequent years.

2.5.4 Summary of Project Effects on Listed Anadromous Fish Species

2.5.4.1 Sacramento River Winter-Run Chinook Salmon

Approximately 50 percent of the average annual winter-run Chinook salmon salvage occurs during the month of March according to data from the CVP and SWP salvage records (1999-2009). For the months of April, May, and June combined, the number of winter-run Chinook salmon smolts collected at the CVP and SWP facilities falls to approximately 3 percent of the annual salvage numbers.

This indicates that approximately half of the total annual salvage estimate for winter-run Chinook salmon smolts would be exposed to the construction actions of the TBP and of those that were exposed to the construction activities, most would experience adverse conditions on the level of harassment rather than levels resulting in injury or mortality. In contrast, those winter-run Chinook salmon smolts present in the action area following completion of the barriers would be more vulnerable to predation due to the higher concentration of predators in the area and the alteration in flow patterns created by the barriers that would enhance predator success.

2.5.4.2 Central Valley Spring-Run Chinook Salmon

The proposed installation schedule for the temporary barriers as early as March 1 each year will occur just prior to the peak of Central Valley spring-run Chinook salmon smolt outmigration in the Delta as measured by the salvage records from the CVP and SWP. As described previously, a small proportion of the spring-run Chinook salmon are expected to be present in the action area during the actual construction phase of the barriers. The construction phase of the TBP is expected to result primarily in conditions that harass exposed fish through elevated sounds and turbidity, but not result in conditions that would cause imminent mortality directly related to the construction activity.

Approximately 98 percent of the annual spring-run Chinook salmon salvage occurs in the months of March, April, and May, as indicated by the salvage records from 1999 through 2009. By the end of May, the proportion of spring-run Chinook salmon outmigrants through the south Delta has declined markedly, with the outmigration of spring-run Chinook salmon smolts essentially concluding by the end of June. NMFS believes that juveniles of the spring-run Chinook salmon population that have been drawn into the south Delta by the actions of the CVP and SWP pumps during this time period become susceptible to the effects of the barriers. In particular, those fish that move with the tidal circulation patterns in the western channels of the south Delta (Middle River near Union Point, Old River near the CVP facilities, and the GLC system near the SWP Clifton Court radial gates) have a high probability of encountering predators around the ORT, MR, and GLC barriers. As explained in the previous sections, flow patterns in the interior of the south Delta are altered due to the installation of the barriers, and unique nearfield flow conditions are created at the barriers themselves. This environment enhances the potential risk of mortality for Chinook salmon smolts in the south Delta. The creation of barriers to free movements of fish in the main channels, the concentration of predators at key “choke points” in those channels (i.e., at the barrier locations), and the creation of a “recirculating” flow pattern elevate the risk of mortality for those Chinook salmon smolts entering the action area.

2.5.4.3 California Central Valley Steelhead

The data from the CVP and SWP salvage records indicate that approximately 60 percent of the annual steelhead salvage occurs prior to the proposed installation date of the temporary barriers in the beginning of March. Unlike the winter-run and spring-run Chinook salmon, CCV steelhead occur in both the Sacramento and San Joaquin River basins. Therefore, this species can enter the south Delta action area from both HOR on the eastern side of the south Delta and also from the western side of the south Delta due to the influence of the state and Federal pumps pulling water and fish southwards through the Delta from both the Sacramento River basin and the San Joaquin River main stem. Due to the geographic location of the barriers in the south Delta, the populations of steelhead originating in the San Joaquin River basin are at a higher risk of being exposed to the direct effects associated with the construction and operation of the TBP than those originating in the Sacramento River basin due to the proximity of the channels where the barriers are installed to the emigration routes they must follow to access the ocean. Steelhead smolts emigrating from the Sacramento basin can still become entrained in the south Delta by various pathways and become exposed to all of the effects associated with the construction and operation of the agricultural barriers however. Steelhead that pass down the main stem of the San Joaquin River towards Stockton must also face the concentrations of predators that inhabit that stretch of river, as described in the accounts for the acoustic tagging studies done in the VAMP experiments. Survival appears to be enhanced for Chinook salmon smolts following this route, as compared to those that take a path through the south Delta. However, overall survival is still quite low for either path taken based on the survival estimates generated from fish recoveries. NMFS expects that steelhead smolts, although larger than fall-run Chinook salmon smolts, would also face high levels of predation, particularly from striped bass, while emigrating down the main stem of the San Joaquin River. Recent studies by DWR in Clifton Court Forebay (DWR 2009) examining the rate of loss of acoustically tagged steelhead smolts within the forebay (assumed to be primarily the result of predation) indicate that steelhead smolts and Chinook salmon smolts have similar levels of loss, even though the steelhead are considerably larger fish. Steelhead smolts entering the channels of the south Delta would encounter the effects of the agricultural barriers, including turbulent water flows over the barriers and elevated concentrations of predators associated with the barriers.

The spring HOR barrier will be operated during a period of time when the probability of CCV steelhead from the San Joaquin River Basin being present in the south Delta is high based on historical monitoring of the rotary screw traps on the Stanislaus River and the recovery of steelhead smolts in the Kodiak trawls conducted at Mossdale by CDFW and FWS during the spring. With the spring HOR barrier in place, steelhead smolts will be prevented from entering the Old River channel from the main channel of the San Joaquin River, and thus continue downstream in the San Joaquin River towards the Port of Stockton., Although these smolts will have an improved chance of avoiding the entrainment and predation risks associated with the channels of the south Delta by staying in the mainstem San Joaquin River below the confluence with Old River, there is still a possibility that they could enter other channels downstream leading into the interior of the South Delta with waters flowing towards the ocean, and thus become entrained and potentially exposed to the effects of the TBP depending on their ultimate migratory pathway.

2.5.4.4 Southern DPS of North American Green Sturgeon

NMFS anticipates that green sturgeon will be present in the south Delta during the spring installation of the temporary barriers. Based on the salvage recoveries of green sturgeon at the CVP and SWP, they are most likely to be in the western channels of the south Delta, but their presence in the main stem of the San Joaquin River cannot be completely ruled out. Green sturgeon have the potential to become trapped behind the barriers following their construction. Based on the observed behavior of green sturgeon, they are unlikely to swim over the crest of the weir to escape confinement upstream of the barriers. However, prior to the full operation of the barriers, movement upstream and downstream might be possible through the culverts. Following full barrier operations, this becomes impossible due to the tidal flaps closing on the outgoing tide, thus blocking passage downstream through the culverts. The only avenue of escape from the south Delta channels would be to swim upriver to the confluence of the Old River channel with the San Joaquin River and then swim downstream within the San Joaquin River main stem to the DWSC. Should green sturgeon become entrapped upstream of the barriers, they would be unable to escape the increasing warming of the water in the south Delta channels as summertime air temperatures increase in the region. Summer water temperatures can exceed 80°F in the south Delta. As water temperatures increase, DO also declines, creating zones of hypoxia which may further block movements in the south Delta exacerbating the situation by exposing those fish to the compounding effects of multiple stressors that could either lead to the mortality of individual fish or effectively leave them stranded until barrier removal in the fall. Summertime water quality also decreases in the south Delta channels due to increasing agricultural discharges and stagnation of flushing flows. In addition, the annual disturbance to the channel bottom imposed by the physical installation and presence of the barriers is likely to preclude the development of climax communities of benthic invertebrate populations, which could thereby affect the availability and density of suitable prey items for rearing and migrating sturgeon in the action area. NMFS does not anticipate that the juvenile sturgeon present in the south Delta action area will be subject to predation by striped bass or other piscivores, however, due to their comparatively larger size (> 200 mm) at Delta entry and the formation of protective scutes on their body which may serve as a deterrent.

2.5.5 Project Effects on Critical Habitat

As described earlier, the action area is within the designated critical habitats for CCV steelhead and Southern DPS green sturgeon, but not Sacramento River winter-run or Central Valley spring-run Chinook salmon.

The installation of the agricultural barriers directly impacts approximately 58,500 square feet of channel bottom (1.34 acres). The ORT barrier has a footprint of approximately 250 feet by 60 feet (15,000 square feet), while the GLC barrier has a similar sized footprint of 300 feet by 100 feet (30,000 square feet). The MR barrier has a footprint of 270 feet by 50 feet (13,500 square feet). The annual duration of the physical "smothering" of the channel bottom by the barriers' rocky substrate lasts approximately 9 months (March through November) for the three agricultural barriers. The spring HOR barrier footprint has dimensions of 225 feet by 85 feet (19,125 square feet) and the fall HOR barrier has a footprint of approximately 225 feet by 65 feet (14,625 square feet). Both the spring and fall HOR barriers may remain in the channel for up to 60 days, depending on the management goals of the CDFW in the case of the fall barrier. NMFS expects that the regular disturbance of the channel substrate by the installation and removal of the barriers will prevent the establishment of a normal climax benthic community within the footprints of the four barriers. The high level of disturbance experienced within these areas would preferentially favor non-native species which could rapidly colonize the disturbed substrate.

The channels of the south Delta have been extensively modified by human activities. The channel edges have been heavily riprapped and the channels no longer have normal fluvial function. Channels cannot migrate within their natural floodplain, but rather are constricted to the region between the two leveed banks. Riparian growth has generally been limited to narrow bands along the base of the levee banks where siltation has allowed shallow berms of sediment to accumulate. Along these narrow bands, stands of tules and rushes have taken root and created pockets of emergent vegetation, which in turn have created small low-lying islands, particularly in Middle River and the central portion of Old River. Some of these islands have sufficient elevation to allow shrubs and trees to grow on them. In winter, when the temporary barriers are removed, the channels and their stands of emergent vegetation are exposed to the full tidal range of approximately 5 feet (from 2 feet below msl to 3 feet above msl). When the temporary barriers are in place, the tidal range is muted, and the lower range of the tide is held artificially high (i.e., 1 foot above msl). The "intertidal" range is reduced and vegetation that would normally have been exposed at low tide is submerged during the periods when the barriers are in use by up to 3 feet of water. This inundation pattern is likely to change the profile of the emergent vegetation community, which is likely to have an effect on the density of both predators and prey within the action area.

Likewise, as explained previously, the barriers create impediments to free movement of fish within the channels of the south Delta affected by the placement of the barriers. They also create structure which attracts predatory fish and enhances their foraging success on juvenile salmonids passing through the reaches affected by the placement of the barriers.

2.6 Cumulative Effects

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

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

2.6.1 Agricultural Practices

Agricultural practices in the Delta likely negatively affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect salmonid reproductive success and survival rates (Dubrovsky et al. 1998, 2000; Daughton 2003).

2.6.2 Increased Urbanization

The Delta, East Bay, and Sacramento regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. The anticipated growth will likely occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation process with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This will potentially degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the Delta. 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.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

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

The Status of Species and Environmental Baseline sections show that past and present impacts to the San Joaquin River basin and south Delta have caused significant salmonid and green sturgeon habitat loss, fragmentation and degradation. This has significantly reduced the quality and quantity of freshwater rearing sites and the migratory corridors within the lower valley floor reaches of the San Joaquin River and the south Delta for these listed species. Additional loss of freshwater spawning sites, rearing sites, and migratory corridors have also occurred upstream of the south Delta in the upper main stem and tributaries of the San Joaquin River.

Anthropogenic activities in the San Joaquin River watershed have contributed substantially to declines in CCV steelhead and Southern DPS of North American green sturgeon populations and have led to the extirpation of the Central Valley spring-run Chinook salmon populations endemic to the San Joaquin River Basin's watersheds (e.g., completion of Friant Dam and the Kern and Friant canals in the late 1940s). Dam operations have reduced the extent of suitable water temperatures for over summering steelhead juveniles to the tailwaters immediately below these dams. In some cases the water temperatures reach incipient lethal temperatures only a few miles downstream of the dams. Alterations in the geometry of the south Delta channels, removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by demands of water diverters (including pre-1914 riparian water right holders, CVP and SWP contractors, and municipal entities), and the influx of contaminants from agricultural and urban dischargers have substantially reduced the functionality of the action area's aquatic habitat. The proposed action, the installation and operation of the temporary barriers by DWR, has now been occurring for over 20 years (since 1991) and, thus, the effects of these past operations are also a part of the environmental baseline. The effects of past and present activities examined in the environmental baseline are expected to extend into the future for the duration of the proposed TBP through the year 2022.

2.7.2 Summary of Effects of the Proposed Action on Listed Species and Critical Habitat

The proposed action is expected to continue to affect the value of the action area as functional freshwater migration and rearing habitat for an additional 5 years. These effects are a continuation of the effects that have occurred for the past 25 plus years due to the annual implementation and ongoing nature of the operations of the temporary barriers program. The TBP will degrade existing functional habitat characteristics during the 9-month period (March through November) the barriers may potentially be in place each year (e.g., free movement of fish, passage obstructions, increased predation, creation of lentic conditions, changes in channel flora and fauna populations, alterations in water quality parameters, etc.). The remaining 3 months of the year (December through February) will allow for some recovery of habitat conditions, including free movement of fish through the channels of the south Delta, and enhancement of water quality parameters related to flow patterns and tidal exchange. However, the impacts of the barrier placements each year will not be fully ameliorated by this short reprieve as the installation and removal are cyclical events and do not allow for a stable, natural habitat to become re-established in the action area.

The small numbers of juvenile spring- and winter-run Chinook salmon that end up in the south Delta rely on the physical and biological attributes of the south Delta channels to provide rearing and migrational functions for their survival. Critical habitat has been designated for the Southern DPS of green sturgeon including the south Delta, and the elements of the critical habitat present in the south Delta are considered necessary for the continuing survival of the Southern DPS of green sturgeon. Installation of the temporary barriers fragments habitat and restricts free movement of fish in these channels and elevates the risk of predation or mortality from other sources (i.e., poor water quality, contaminants, etc.).

The impacts described in the Cumulative Effects section are expected to further diminish the functional value of critical habitat within the action area. For instance, increased demands for water, whether for agricultural purposes or for domestic consumption are expected to continue in the south Delta. The region's pre-1914 riparian water right holders have the senior rights to divert water in the action area, and are not expected to decrease their water diversion entitlements for environmental purposes. Likewise, regional urban development is expected to continue, although the rate of development may slow due to economic pressures in the area. Therefore, the demand for domestic and municipal water supplies diverted from the south Delta and San Joaquin River Basin are expected to increase to meet these demands in future years, although the rate of increase may moderate in the near term due to economic trends. As urban development increases in the area the ability to modify or enhance the riparian zone of the south Delta channels will be lessened in response to flood management needs for urbanized areas. This circumstance will perpetuate the already degraded status of the critical habitat in the action area, add to the adverse effects of the proposed action, and reduce the potential of future environmental restoration actions such as setback levees or flood benches along the river channels.

2.7.2.1 Sacramento River Winter-Run Chinook Salmon

Based on the CVP/SWP salvage data, nearly 47 percent of the annual winter-run Chinook salmon salvage has occurred in the south Delta by the proposed installation date of the temporary barriers in the beginning of March. Therefore, approximately 53 percent of the annual winter-run Chinook salmon presence in the south Delta can be affected by the installation and operations of the temporary barriers.

2.7.2.2 Central Valley Spring-Run Chinook Salmon

Individuals from the Central Valley spring-run Chinook salmon ESU are more likely to be affected than the winter-run Chinook salmon ESU due to the later peak in their outmigration. Based on the salvage data from the CVP/SWP, more than 99 percent of the annual spring-run Chinook salmon salvage occurs from March through June. Therefore, practically all of the spring-run Chinook salmon presence in the south Delta waterways will occur after the installation of the temporary barriers.

2.7.2.3 California Central Valley steelhead

Outmigrating steelhead smolts from the Sacramento River basin and other tributaries outside of the San Joaquin River Basin account for most of the nearly 4,000 total fish (clipped and unclipped) salvaged at the CVP/SWP facilities during the months of March, April, May, and June. Hatchery fish (clipped) are more prevalent in March and April than they are in May and June, indicating that San Joaquin River Basin fish may make up a greater percentage of the wild fish in late spring recovered at the CVP/SWP facilities as a result of the VAMP flow increases in the basin stimulating the steelhead to emigrate from their natal streams. Estimates for juvenile production in the San Joaquin River Basin are unavailable due to a lack of data. Since typically less than a dozen steelhead smolts per year are captured in the Mossdale monitoring trawls, juvenile production does not appear to be very high in the basin. In contrast, the Sacramento River basin is estimated to have an annual wild fish production of approximately 181,000 smolts per year.

The steelhead population in the San Joaquin River basin is susceptible to activities in the south Delta which impact the ability of adults and juveniles to successfully move through this region. The temporary barriers are expected to create impediments to free fish movement and passage in the waterways of the south Delta, leading to increased rates of mortality due to higher predation, degradation of water quality, and prolongation of migration through the system without sufficient rearing capacity. These negative impacts diminish the ability of the population to respond to larger environmental stressors in the watershed. Small, discrete subpopulations, such as those steelhead populations found in the San Joaquin River basin, are highly susceptible to extirpation from ongoing actions which decrease the spawning success rate, rearing capacity or ability of the individual fish to migrate to and from the ocean effectively. Currently the larger population of CCV steelhead is in decline and the role of these smaller populations becomes important in maintaining spatial and genetic diversity within the DPS. They may serve as sources of genetic variability, spatially separated population pools to minimize the risk of local extinctions, and sources of new founder populations in the event of a local extinction event.

The magnitude and significance of the effects of the TBP on CCV steelhead is impossible to quantify due to a lack of monitoring and scientific data. Current unknowns include the proportion of each year class that will be exposed to the barriers and the degree of negative effects on those fish that do encounter the barriers. The limited information that is available indicates that the annual installation and operations of the TBP is likely to reduce the survival rate of those fish that are exposed to the effects of the barriers. However, the installation and operation of the spring HOR barrier will reduce the impacts of the TBP by preventing emigrating fish from entering Old River and encountering the higher losses associated with this route through the Delta to the ocean.

2.7.2.4 Southern DPS North American Green sturgeon

Juvenile and sub-adult life stages of the Southern DPS of green sturgeon rear year round in the waters of the Delta and are therefore expected to be exposed to the effects of the temporary barriers over their entire 9-month installation and operational period. There are no reliable estimates of juvenile production, and no estimates of the number of individuals rearing in the south Delta action area, so the population level of exposure is unknown. Those green sturgeon juveniles and sub-adults that do enter the action area are likely to experience habitat fragmentation, reductions in free movement through the channels of the south Delta, and potential entrapment behind the barriers during the periods of seasonal operations.

2.7.3 Summary

The combined effects of the proposed action will have mixed consequences on listed fish in the south Delta action area. The temporary barriers will seasonally diminish or degrade designated critical habitat for CCV steelhead and the Southern DPS of North American green sturgeon, as well as habitat for CV spring-run Chinook salmon and Sacramento River winter-run Chinook salmon in the action area with beneficial effects for the listed fish species migrating through the San Joaquin River basin. The presence and operations of the temporary barriers will also increase the extent of mortality related to predation, delays in migration to the ocean, and exposure to degraded water conditions. These effects are expected to occur primarily during the 9 months of the year when the temporary barriers are installed. The remaining 3 months of the year will see only residual effects associated with habitat alterations incurred during the 9 months of barrier operation (e.g., changes in macroinvertebrate density and populations, extent of riparian and emergent vegetation levels, etc.).

The fall HOR barrier is installed in the September to November time frame at CDFW's request to help ameliorate low DO conditions in the Stockton DWSC adjacent to the Port of Stockton, which is a benefit to San Joaquin River basin fish. Due to the fish passage notch cut into the top of the barrier, delay of adult steelhead should be minimal for those fish migrating up river through the waterways of the south Delta.

The proposed implementation of the TBP is expected to reduce the functionality of the PBFs of the designated critical habitat for CCV steelhead and the Southern DPS of North American green sturgeon in the south Delta. This will occur on a seasonal basis that will continue for an additional 5 years of implementing the proposed TBP. Passage for emigrating steelhead will still be possible through the main stem channel of the San Joaquin River but will be diminished within the south Delta channels due to the presence of the temporary barriers except in those years when the spring HOR barrier is installed. While the majority of CCV steelhead generally migrate through the action area prior to the installation of the temporary barriers, the survival of fish emigrating later in the spring when the barriers are installed is expected to be reduced by the effects of the TBP, except in those years when the spring HOR barrier is installed. The TBP is not anticipated to have any permanent impacts on critical habitat designated for CCV steelhead or the Southern DPS of North American green sturgeon.

For Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and CCV steelhead (Sacramento River origins) populations that are drawn into the south Delta and exposed to the operations of the barriers, mortality is expected to increase. The proportion of the total juvenile production for these Central Valley populations lost to the effects of the barriers is expected to be extremely low, based on the current estimates, and thus should not have any demonstrable effect on these populations.

2.8 Conclusion

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon, the environmental baseline, the effects of the annual implementation (i.e., construction, operation, and removal) of the proposed Temporary Barriers Program for a period of 5 years, and the cumulative effects, it is NMFS' biological opinion that implementation of the TBP during the years 2018-2022 is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, or the Southern DPS of North American green sturgeon, nor will it result in the destruction or adverse modification of designated critical habitat for CCV steelhead or the Southern DPS of North American 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 this opinion, NMFS determined that the proposed action is reasonably certain to result in the incidental take of individual Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon. Incidental take associated with this action is expected to be in the form of mortality, harm, or harassment of juvenile winter-run and spring-run Chinook salmon, adult and juvenile CCV steelhead, and juveniles from the Southern DPS of North American green sturgeon. This incidental take is expected to occur as a result of exposure to the construction of the temporary barriers in spring. Some of the harm associated with this exposure could be the result of being crushed by the rock barrier material as it is deposited in the river, harassment from the generation of underwater noise associated with the construction process, increased vulnerability to predation, and the impedance of free migratory movements within the south Delta during the operational period of the temporary barriers. Incidental take of juvenile Sacramento River winter-run and CV spring-run Chinook salmon, as well as both adult and juvenile CCV steelhead, is expected to occur during the period from March 1 to June 30, when individuals from these populations could potentially be present in the action area. Adult CVC steelhead are also expected to be present during the fall (September through November) to varying extents during their upstream spawning movements into the San Joaquin River basin. Juveniles and sub-adults from the Southern DPS of North American green sturgeon are expected to be present in the action area year round and would overlap with the 9-month operational period of the TBP (March through November).

NMFS cannot, using the best available information, accurately quantify the anticipated incidental take of individual listed fish because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the TBP area. However, it is possible to designate ecological surrogates for the extent of take anticipated to be caused by the TBP, and to monitor those surrogates to determine the level of take that is occurring. The most appropriate ecological surrogates for providing a quantifiable metric for determining the extent of incidental take of listed fish caused by the construction and operation of the TBP are: (1) the level of acoustic noise in the aquatic environment generated during the construction and removal phase for each barrier, (2) the extent and duration of turbidity increases in the aquatic environment relative to environmental background conditions during construction of the barriers, (3) the total size of the physical footprint of each barrier to be constructed, and (4) the period of time that each barrier will be in place during the year. Of these, the measurements of acoustic noise and turbidity increases in the aquatic environment resulting from the construction and removal of the barriers can be consistently and accurately measured during project implementation, and therefore serve as physically measurable proxies for the incidental take of listed fish. NMFS assumes that the project proponent will adhere to the project description provided for the purposes of the section 7 consultation.

Ecological Surrogates

- The analysis of the effects of the proposed TBP anticipates that the construction and removal of each barrier will result in acoustic noise generated in the aquatic environment that exceeds typical ambient background conditions for the action area. Based on the types of vehicles and equipment to be used, the methods described for construction and removal of the barriers, and the effects analysis conducted for this consultation, the amount of sound generated in the aquatic environment associated with the construction and removal of each barrier is not expected to exceed 150 dB at a distance of 100 meters from the source activity at any time.

- The analysis of the effects of the proposed TBP anticipates that the construction and removal of each barrier will result in increases to the ambient background levels of turbidity in the aquatic environment downstream from the barrier installation sites. Based on the types of materials to be used to construct the barriers, the methods described for construction and removal of the barriers, and the effects analysis conducted for this consultation, the observed increases in turbidity above ambient background conditions in the aquatic environment shall not exceed 15 NTUs in successive samples at a distance of 100 meters upstream and downstream from the construction site.

If the limits to the extent of incidental take represented by these ecological surrogates are not met and maintained, the proposed TBP will be considered to have exceeded anticipated take levels, triggering the need to reinitiate consultation on the TBP.

In addition to the incidental take of listed species associated with the construction, operation, and removal of the four barriers associated with the TBP each year, NMFS anticipates that incidental take of these listed species may also occur as a result of the implementation of future predatory fish study plans that will be proposed in conjunction with operation of the TBP. This programmatic biological opinion does not specifically analyze the effects of, or explicitly authorize incidental take as a result of, the implementation of future predatory fish study plans in association with the temporary barriers program. Those future actions will be analyzed separately and incidental take authorized through the section 7 process if NMFS determines they will not jeopardize the continued survival and recovery of the listed species under consideration.

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

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

1. The Corps and DWR shall avoid or minimize construction-related impacts associated with the implementation of the TBP upon juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and Southern DPS of North American green sturgeon.

2. The Corps and DWR shall develop an adaptive management protocol to reconcile future operations of the TBP with fisheries needs in the south Delta.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps and DWR must comply with them in order to implement the RPMs (50 CFR 402.14). The Corps and DWR have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

a. Monitoring of turbidity levels generated by the construction and removal of each barrier shall be conducted to verify that water quality criteria are not exceeded, as described in the description of ecological surrogates above. If levels are exceeded, NMFS shall be notified and work halted until corrective actions are instituted to achieve surface water quality criteria.

b. Stockpiling of construction materials including rocks, gravel, flexible cement matting, portable equipment, vehicles and supplies, including chemicals and chemical containers, shall be restricted to designated construction staging areas and exclusive of the riparian areas.

c. All heavy equipment shall be fueled, maintained, and stored at a safe distance from any adjacent waterways. Standard construction BMPs, as described in the current California Department of Transportation Construction Site Best Management Practices Manual (Caltrans 2003), shall be implemented so that no oil, grease, fuel or other fluids contaminate the waterways around the work sites.

d. Erosion control measures that prevent soil or sediment from entering the river during construction, or as a result of construction, shall be implemented and maintained throughout construction, or as needed as described in the Caltrans Construction Site BMP Manual.

e. Any Chinook salmon, steelhead or green sturgeon found dead or injured within 0.1 mile upstream or downstream of construction sites during barrier installation shall be reported immediately to NMFS via fax or by phone:

Attention Supervisor, NMFS California Central Valley Office
Fax: (916) 930-3629
Phone: (916) 930-3600

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

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

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

f. Within 30 days of completing any construction activity associated with the TBP, DWR shall submit a report to the Corps and NMFS describing the work that was performed, the starting and ending dates of the construction actions, any observed adverse effects to aquatic habitats and their duration (*i.e.*, increased suspended sediment levels or turbidity, instances of pollution, unusual animal behaviors in adjacent waters, *etc*.), and any problems encountered during construction activities.

2. **The following terms and conditions implement reasonable and prudent measure 2:**

   a. DWR, in coordination with NMFS staff, shall develop operational protocols to reduce entrainment of San Joaquin River basin CCV steelhead during the spring period.

   b. Actions taken to reduce entrainment of delta smelt shall be coordinated with NMFS to reduce adverse impacts to listed salmonids and green sturgeon in the south Delta region.

   c. DWR shall submit future study plans to NMFS describing the proposed methods and anticipated levels of incidental take of listed species that may be expected to occur as a result of the implementation of predatory fish studies associated with the Temporary Barriers Program. These predatory fish study plans must be submitted to NMFS by January 1st of each year for separate consideration, analysis, and ESA section 7 consultation.

2.10 Conservation Recommendations

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

1. The Corps and DWR should implement biotechnical measures in place of traditional revetment techniques should any of their projects' riprap begin to cause scour and require additional bank stabilization.

2. The Corps and DWR should conduct or fund studies to help quantify fish losses at water diversions, and prioritize fish screen projects for future funding.

3. The Corps and DWR should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects within the Delta region.

2.11 Reinitiation of Consultation

This concludes NMFS formal consultation on the construction and operations of the South Delta Temporary Barriers Program for the years 2018-2022. As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

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

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the Corps and DWR, and descriptions of EFH for Pacific Coast salmon contained in the fishery management plan (FMP) developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The PFMC has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). The proposed project sites are within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP. Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers et al. (1998), and includes the San Joaquin Delta (Delta) hydrologic unit (i.e., number 18040003). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the Delta unit.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, riprapping, etc. (Dettman et al. 1987; California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf et al. 1996a, 1996b).

3.2 Adverse Effects on Essential Fish Habitat

The effects of the proposed action on salmonid habitat are described at length in section 2.5 (Effects of the Action) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS recommends that the terms and conditions of the preceding biological opinion be adopted and implemented along with the following conservation measures in the action area to minimize the effects of the action and encourage the conservation and enhancement of Pacific Coast salmon EFH, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999).

Riparian Habitat Management: In order to prevent adverse effects to riparian corridors, the U.S. Army Corps of Engineers (Corps) should:

- Maintain riparian management zones of appropriate width along Old River;
- Reduce erosion and runoff into waterways within the project area; and
- Minimize the use of chemical treatments within the riparian management zone to manage nuisance vegetation along the levee banks.

Bank Stabilization: The installation of riprap or other streambank stabilization devices can reduce or eliminate the development of side channels, functioning riparian and floodplain areas and off channel sloughs. In order to minimize these impacts, the Corps should:

- Use vegetative methods of bank erosion control whenever feasible. Hard bank protection should be a last resort when all other options have been explored and deemed unacceptable;
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species, before planning new bank stabilization projects; and
- Develop plans that minimize alterations or disturbance of the bank and existing riparian vegetation.

Construction/Urbanization: Activities associated with urbanization (e.g., building construction, utility installation, road and bridge building, and storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and subsequently adversely impact salmon EFH through habitat loss or modification. In order to minimize these impacts, the Corps and the applicant should:

- Plan development sites to minimize clearing and grading;

- Use Best Management Practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoid building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients; and

- Where feasible, reduce impervious surfaces.

Wastewater/Pollutant Discharges: Water quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (e.g., from dredging), and when flow is altered. Indirect sources of water pollution in salmon habitat includes run-off from streets, yards, and construction sites. In order to minimize these impacts, the Corps and the applicant should:

- Monitor water quality discharge following National Pollution Discharge Elimination System requirements from all discharge points;

- For those waters that are listed under Clean Water Act section 303(d) criteria (e.g., the Delta), work with State and Federal agencies to establish total maximum daily loads and develop appropriate management plans to attain management goals; and

- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling and transport of toxic substances in Pacific Coast Salmon EFH (e.g., oil and fuel, organic solvents, raw cement residue, sanitary wastes, etc.). Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

5.1 Utility

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

5.2 Integrity

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

5.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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