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

JUN 3 2016

Refer to NMFS No: WCR-2016-4548

Ms. Alicia E, Kirchner
Chief, Planning Division
Department of the Army
Corps of Engineers, Sacramento District
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 Sacramento and Stockton Deep Water Ship Channels Maintenance Dredging and Bank Protection Project

Dear Ms. Kirchner:

Thank you for your letter of July 17, 2014, requesting reinitiation of formal consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 *et seq.*) for the proposed Sacramento and Stockton Deep Water Ship Channels Maintenance Dredging and Bank Protection Project (project) in Sacramento, Solano, Contra Costa, Yolo, and San Joaquin Counties, California. The U.S. Army Corps of Engineers (Corps) has determined that the project may adversely affect the 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 of the North American green sturgeon (*Acipenser medirostris*), and their respective designated critical habitats. Your July 17, 2014, request for reinitiation of formal consultation was received in our office on July 18, 2014. Formal consultation was reinitiated on April 6, 2015.

This biological opinion is based on information provided in the July 2014 Biological Assessment (BA), information supplemental to the BA provided subsequently through e-mail correspondence, and discussions held at meetings and through telephone conversations between representatives of NMFS and the Corps. A complete administrative record of this consultation is on file at the NMFS California Central Valley Office located in Sacramento, California.

Based on the best available scientific and commercial information, this biological opinion concludes that the Sacramento and Stockton Deep Water Ship Channels Maintenance Dredging and Bank Protection project, as proposed by the Corps, is not likely to jeopardize the continued existence of the listed species listed above, nor likely to adversely modify any of their respective designated critical habitats. NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take associated with the proposed project.

This letter also transmits NMFS' Essential Fish Habitat conservation recommendations for Pacific salmon (*O. tshawytscha*), starry flounder (*Platichthys stellatus*), and northern anchovy (*Engraulis mordax*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq*.). This document concludes that the proposed project will adversely affect the EFH of Pacific salmon, starry flounder, and northern anchovy in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the biological opinion as the EFH conservation recommendations.

Section 305(b)(4)(B) of the MSA requires the Corps to submit a detailed written response to NMFS within 30 days of receipt of these conservation recommendations, and 10 days in advance of any action, that includes a description of the measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the activity on EFH (50 CFR 600.920 (j)). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including 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. If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response.

Please contact Douglas Hampton in the California Central Valley Office located in Sacramento, California by telephone at 916-930-3610 or by email at Douglas.Hampton@NOAA.gov if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

for Maria Rea
William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Division Chon File: ARN#151422-WCR2015-SA00150

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

Sacramento and Stockton Deep Water Ship Channels Maintenance Dredging and Bank Protection Project

NMFS Consultation Number: 151422-WCR2015-SA00150

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
California Central Valley Steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	Yes	No	No
Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*)	Threatened	Yes	Yes	No	No
Sacramento River Winter-run Chinook Salmon (*O. tshawytscha*)	Endangered	Yes	Yes	No	No
Central Valley Spring-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	Yes	No	No

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

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

Issued By:

William W. Stelle, Jr.
Regional Administrator

Date:

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 portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

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

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

1.2 Consultation History

On February 5, 2013, the U.S. Army Corps of Engineers (Corps) met with NMFS to discuss the development of a biological assessment (BA) to support a pending request for consultation under the ESA.

On July 16, 2013, the Corps met with NMFS to further discuss the development of a BA to address the effects of the proposed project.

On March 25, 2014, the Corps and NMFS held an additional meeting to further coordinate on the development of a BA for the proposed project.

On July 18, 2014, the Corps delivered the BA along with a letter to NMFS requesting re-initiation of the 10-year programmatic consultation addressing the effects of maintenance dredging of the Sacramento and Stockton deep water shipping channels.

On February 17, 2015, the Corps and NMFS participated in a teleconference call to discuss the updated status of the BA and consultation.

On March 26, 2015, the Corps delivered a revised BA to NMFS describing the effects of the action.

1.3 Proposed 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).

The Corps proposes to continue to perform routine maintenance dredging and bank protection on the Sacramento and Stockton Deep Water Ship Channels (DWSC) under Indefinite Delivery/Indefinite Quantity (IDIQ) contracts yearly during the 10 dredging seasons from 2016 through 2025. The proposed project includes work performed by using a hydraulic cutterhead dredge (also known as a pipeline dredge) for dredging and a clamshell crane for rock placement. The dredged material would be deposited at previously authorized Dredged Material Placement Sites (DMPS). Dredge slurry would be routed to the DMPS via pipelines. DMPS would be diked in order to allow dredge slurry to settle and consolidate. Decant water would then be discharged back into the Sacramento or Stockton DWSC from whichever DMPS is servicing the area being dredged as determined during annual coordination. Dredged spoils would be allowed to dry in the DMPS. Bank protection rock may be placed at any site that previously contained bank protection work, and where there is a need for additional rock due to bank erosion following specific work windows to minimize impacts.

1.3.1 Dredging

Prior to each proposed dredging season, the Corps will coordinate with NMFS, providing documentation of the exact reaches of the Sacramento and Stockton DWSC to be dredged, the schedule for that dredging season, and identifying which DMPS would be used. If there are changes to DMPS boundaries, location, or function, separate documentation will be provided for NMFS approval. A maintenance dredging work window is proposed to follow a yearly schedule from August 1 to October 31 for the Sacramento DWSC and from August 1 to November 30 for the Stockton DWSC during the 10-year span from 2016 through 2025. All sites will be dredged to maintain the current allowable depth: the downstream portion of the channel will be maintained at a depth of 30 feet below mean lower low water (MLLW), and the upstream portion of the channel will be maintained at a depth of 35 feet MLLW. An allowable over depth of 1 to 2 feet is also anticipated for all sites. These depths maintain safe conditions for ships using the channels while not increasing the quantity or size of commercial navigation traffic. All dredging will be performed using a hydraulic cutterhead suction dredge and all dredged material and dredge slurry will be deposited at a previously authorized DMPS via pipelines. DMPS will be diked and dredge slurry will be allowed to settle and consolidate. Depending on the size of the DMPS and the amount of material being dredged, the decant water could be released from the DMPS into the river. Effluent discharge from all DMPS are done only with prior approval from the Central Valley Regional Water Quality Control Board (CVRWQCB) through the 401 Water Quality Certification.

The quantity of material to be dredged each dredging season will not exceed 500,000 cubic yards. The dredge is expected to operate 24 hours a day, 7 days a week within the identified work windows. When the dredge is positioned in a location where shoaling is to be removed, the dredge is anchored by alternately planting one of two spuds, or vertical poles, into the bottom sediment, and rotating itself around whichever of the two spuds is planted by pulling on swing anchors, alternately raising and planting the spud as the dredge "walks" forward. The hydraulic pipeline dredge is equipped with a rotating cutterhead (excavator) surrounding the intake of the suction line. Excavated solids and a large volume of the surrounding water are passed through the dredge centrifugal pump to the discharge pipeline as slurry, which typically has a solids content of 10 to 20 percent by weight.

Dredging activities will be limited to depths greater than 25 feet, and the cutterhead will be kept within 3 feet of the channel bottom while drawing in water. The cutterhead is mounted on a ladder that is free to pivot in the vertical plane and is rotated down to various depths. The ladder will be mounted on a floating dredge that swings left and right while proceeding along the channel. The dredge can be self-propelled or transported to the area by a tugboat. Typically, the dredge is tended by two tenders that pick up and place the swing anchors as the dredge progresses and can also move the dredge short distances. There are also two outboard engine-powered skiffs that transport crews and conduct the water sampling upstream and downstream of the dredge.

The discharge pipeline will run from the dredge in the channel, across the bank, and onto the relevant DMPS. At all DMPS, a nominal area of the outboard levee will be temporarily disturbed during positioning of the slurry pipe. To minimize disturbance, a survey will be taken of the area immediately prior to pipe placement, and upon completion of the dredging operation any disturbed banks will be restored to pre-project conditions. Annual coordination within the 10 dredging seasons will include consideration of appropriate pipe placement in order to avoid or minimize adverse effects to any listed species or designated critical habitats.

The pipeline is made of durable plastic and will either float or sink depending on the specific gravity of the material it contains. The top of the pipeline will float approximately 2 inches above the water surface when filled with water or air, and would rest on the channel bottom when containing dredged material and water. The dredge contractor will determine the best route for the pipeline (per the disposal plan) in conjunction with a qualified biologist in order to avoid or minimize adverse effects to any listed species or their designated critical habitats. The pipeline will be marked by buoys and/or high visibility paint to warn boaters of its presence. Additional safety measures may include signs, flaggers, and/or other measures as required.

1.3.2 Dredged Material Placement Sites

A total of 11 different landward areas are used as DMPSs in conjunction with the planned annual maintenance dredging. Five of these DMPS will service the Sacramento DWSC and six will service the Stockton DWSC. The majority of these areas have been utilized over multiple years and do not provide suitable habitat for riparian species. A brief description of each of the DMPS follows.

1.3.2.1 Sacramento DWSC Dredged Material Placement Sites

1. Grand Island, S-14

   This DMPS is located on the southern tip of Grand Island at the confluence of the Sacramento River, Steamboat Slough, and the Sacramento DWSC in Sacramento County. These are shallow ponds adjacent to the Sacramento / Steamboat Slough. Water is available throughout the year from the river, runoff, and seepage. Regular channel maintenance consists of dredging the ponds. Approximately half of this DMPS is useable, while the remainder is heavily wooded. This DMPS has not been used as a DMPS since 2000.

2. Rio Vista, S-16

   This DMPS is located on the west bank of the Sacramento River just south of the City of Rio Vista in Solano County. The site is a seasonal wetland, but dredged material will be placed in non-wetland areas of the site. The water that carries the material drains into the wetland areas and eventually recedes via culvert into the river. This site has been used as a DMPS in 2000, 2006, 2008, 2010, 2011, and 2013.

3. Decker Island, S-19

   This DMPS is located on the central western portion of Decker Island in the vicinity of a commercial sand mining operation in Solano County. The great majority of the area consists of sand spoils partially vegetated with common herbaceous species. A portion of the site contains a seasonal wetland and holding pond, but dredged material will be placed in non-wetland areas of this site. Water that carries the dredged material drains into the wetland areas and eventually recedes via culvert into the river. This site has been used as a DMPS in 2000-2003 and 2006-2008.

4. Augusto Pit, S-20

   This DMPS is a small, flat parcel on Sherman Island in Sacramento County. Water on the site may pond within areas excavated in uplands creating seasonal wetlands, but as such these areas are not considered jurisdictional waters of the United States. This site has been used as a DMPS in 2001, 2002, and 2005.

5. S-31

   This DMPS is located along the western bank of the Sacramento DWSC between the channel and the Yolo Bypass in Yolo County. The lower slope of the ship channel is vegetated by a mosaic of emergent vegetation at the water's edge, with grasses, scattered willows and blackberry bushes higher on the bank away from the water. The berm area is the portion of the site that will be used for the placement of dredged material. The majority of the berm area is vegetated with grasses and is grazed by cattle and goats. The remaining portions of the berm between the channel and the levee are vegetated with oak woodlands and mixed riparian vegetation. A toe drain and the Yolo Bypass border the west side of the levee. Overstory vegetation includes very few large trees along either the toe drain or channel, good cover on the east bank of the toe drain, and thick riparian vegetation on the west bank. There is not much observable aquatic vegetation in the channel, but there is some along the bank and there is a thin row of riparian vegetation along the west bank of the toe drain. This site has been used as a DMPS in 2000, 2001, 2003, 2005, 2007-2011, and 2013.

1.3.2.2 Stockton DWSC Dredged Material Placement Sites

1. Roberts Island I

This 250-acre site is located on Roberts Island, northwest of the West Complex, Port of Stockton, and adjacent to House Road in San Joaquin County. This site is bermed and has a matrix of bare sand and short herbaceous vegetation. The landing allowance is 300 feet and the Port of Stockton maintains the site. This site has been used as a DMPS in 2000, 2003, and 2006-2012.

2. Roberts Island II

This 220-acre site is located on Roberts Island, between the outlet of Black Slough and the Windmill Cove marina in San Joaquin County. The site is bermed and primarily consists of clay soils with little vegetation. The landing allowance is 600 feet and the site is maintained by the Port of Stockton. This site has been used as a DMPS in 2000, 2001, 2003-2005, and 2009-2011.

3. Bradford Island

This 110-acre site is located on the southwestern portion of Bradford Island, at the confluence of the San Joaquin and False rivers in Contra Costa County. The site is bermed and is currently irrigated pastureland. There are drainage ditches that transect a portion of the site and there is evidence of subsidence. There is some ponded water on site which will be avoided during dredged material placement. The water that carries the dredged material may drain into the ponded areas and eventually recede via a culvert into the river. The landing allowance is 500 feet and the site is maintained by the Port of Stockton and Reclamation District (RD) 2059. This site has been used as a DMPS in 2000, 2003, 2006, and 2010.

4. McCormick Pit

This 26-acre site is located on Sherman Island, east of the Antioch Bridge along the Stockton DWSC in Sacramento County. The site is bermed and contains sand material from past maintenance dredging. There is an emerging freshwater marsh located on a portion of this site as a result of past placement of dredged materials. The marsh contains wetland vegetation that includes a tule reed and cattail mix, along with a mixture of medium aged willows and tall herbaceous cover. Dredged material will be placed in non-wetland areas of this site. The water that carries the dredged material drains through the wetland areas into an agricultural drainage canal on Sherman Island which is pumped back to the river by RD 341. This site contains underlying peat and has a landing allowance of 3,700 feet. The site is maintained by the California Department of Water Resources (DWR) and RD 341. This site has been used as a DMPS in 2002, 2008-2011, and 2013.

5. Scour Pond

   This 125-acre site is located on Sherman Island, west of the Antioch Bridge in Sacramento County. Some areas on this site are already bermed, while others will receive berms prior to use as a DMPS. The existing berm is located outside the marsh fringe around Scour Pond and is currently pastureland. A 200-foot buffer will be maintained around Scour Pond, and no decant water or dredged materials will be placed or allowed to drain into the Scour Pond portion of the site. This site contains underlying peat and has a landing allowance of 900 feet. The site is maintained by DWR and RD 341. This site has been used as a DMPS in 2007-2011, and 2013.

6. Antioch Dunes

   The Antioch Dunes National Wildlife Refuge is an approximately 55-acre refuge managed by the U.S. Fish and Wildlife Service (FWS) that consists of two parcels separated by a Georgia-Pacific Gypsum Plant and a Pacific Gas and Electric utility easement. The refuge was founded in 1980 and is located along the shoreline of the San Joaquin River in Antioch, California in Sacramento County. The western parcel, the 41-acre Stamm Unit, is the only unit proposed to receive dredged material from this project. The site is surrounded by industry including a gypsum plant, a former shipyard, and a former wastewater treatment facility, which now functions as a municipal landfill. As part of the Comprehensive Conservation Plan (CCP) for the Antioch Dunes National Wildlife Refuge, dune restoration is one of the primary objectives for habitat restoration. Beginning in 1991, the FWS has imported sand to the refuge in order to create additional habitat. The CCP calls for identifying potential sources of clean sand, specifically from the Stockton DWSC, and importing the sand for habitat restoration. This site has been used as a DMPS in 2013.

1.3.3 Bank Protection

Suitable rock protection will be placed at eroded sites. Where scour, wash, settlement, or failure of a portion of the original stone protection has been noted, or where inspection indicates that such damage may result during the next flood or high water period, the scour or wash will be filled with earth free from brush, roots, sod, or other unsuitable material and additional stone will be placed upon the earth fill. This maintenance bank protection will bring the rock protection to its original section, using rock fill, embankment, filter, and quarry rock. The rock used will, as much as possible, be similar to the kind and gradation as originally used and described in the 1980 and 1986 Environmental Impact Statement documents.

Along reaches of the Sacramento and Stockton DWSC where filter material was originally placed or where it may be required, maintenance repair of rock protection will include the placement of a properly graded filter layer under the rock protection. In the event an inspection reveals that due to scour, settlement, or other causes, rock protection on the bank is required beyond the limits of the original construction or in reaches of the bank not originally provided with such protection, the Corps will provide additional sloping of the bank and placement of rock protection, as needed, to protect completed works.

Activities in shallow water habitats will be avoided to the fullest extent possible. However, proposed maintenance bank stabilization work may involve some shallow water areas. This maintenance bank protection work is located along both banks of the manmade portion of the Sacramento DWSC at various locations. Rock may be placed at any site that previously contained bank protection work, and where there is a need for additional rock due to bank erosion. On the Stockton DWSC, the maintenance bank protection work is located along the right and left banks, between approximately river mile (RM) 4.0 and 42.0. Authorized sites are those within 1,000 feet from the centerline of the Stockton DWSC. Rock may be placed at any site that previously contained bank protection work, and where there is a need for additional rock due to bank erosion.

A maintenance bank protection work window is proposed to follow a yearly schedule from June 15 to November 30 during each year of the 10-year period from 2016 through 2025 in order to minimize the exposure of listed species to the temporary effects associated with work performed either in the water or in close proximity to the shoreline.

1.3.4 Proposed Conservation Measures

The following conservation measures have been proposed by the Corps:

1. All decant water will be monitored for Central Valley Regional Water Quality Control Board (CVRWQCB) constituents of concern and physical parameters. Management practices will include placing flash boards at the spillway of DMPSs to increase the retention time, using interior dikes within the DMPSs to increase the hydraulic efficiency of the DMPSs, and varying the dredge production rates. Decant water will only be discharged to the river if it meets all of the water quality standards stated in the CVRWQCB Waste Discharge Requirements General Order. If the water does not meet those standards, then it will be retained on the relevant DMPS until further analyses reveal such compliance. The effluent will not exceed water quality objectives or criteria for any constituent that is on the Clean Water Act section 303(d) list.

2. The effects to water quality will further be minimized by not allowing the release of oils, grease, waxes, or other materials that could form a visible film or coating on the water surface or on the stream bottom or creating a nuisance or adversely affecting beneficial uses. Any spills of hazardous materials will be cleaned up immediately and reported in compliance reports.

3. The dredge will not be operated when the cutterhead is off the river bottom. The cutterhead will be buried in the sediment of the river bed during maintenance dredging activities or raised no more than 3 feet off the river bottom when the pumps are operating.

4. Suction will not be employed as the dredge head is deployed and retrieved through the water column until the cutterhead is on the bottom. The suction head will be maintained at a constant elevation near the channel bed when dredging to reduce the field of influence where fish might become entrained into the dredge pipe.

5. Additional hydraulic dredging practices included in the conservation measures include reducing the rotation speed of the cutterhead which minimizes the amount of substrate material sidecast or resuspended into the overlaying water column and reducing the speed of the arm swing which ensures that the cutterhead is not moving faster than its ability to pump the dredged material, and that all of the removed material is pulled into the orifice of the dredge intake pipe.

6. The contractor will be responsible for providing erosion and sediment control measures in accordance with Federal, State, and local laws and regulations to ensure compliance with water quality standards. This will be accomplished by implementing temporary and permanent erosion and sediment control best management practices. These may include, but are not limited to, use of vegetation cover, stream bank stabilization, slope stabilization, silt fences, construction of terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. Any temporary measures will be removed after the area has been stabilized.

7. A Corps representative will be identified as the point of contact for any contractor who might incidentally take a listed salmonid species or sturgeon, or find dead, injured, or entrapped listed sturgeon or salmonids. This point of contact will be identified to all construction employees during an orientation regarding the potential effects of the proposed project on listed steelhead, sturgeon, and Chinook salmon species. The orientation will be conducted by a qualified fisheries biologist and cover specific information on measures to prevent injury to listed fish and what to do if any are found in the project area.

8. NMFS will be notified immediately if a salmon, steelhead, or sturgeon is found dead or injured. Follow-up written notification within 72 hours will include the date, time, and location of the dead or injured specimen, a photograph, cause of injury or death, and name and agency affiliation of the individual who found the specimen.

9. The Corps, through the dredging contractors, will coordinate with NMFS on any plans to mitigate for the loss of riparian habitat with no net loss of quantity or quality.

10. Dredging at depths of less than 25 feet will be avoided at all times.

11. The point at which the dredge material pipeline crosses the levee and discharges into the DMPS will be the position at which the pipeline is securely fixed to the levee so that the pipeline will not drag along the levee.

12. Overflow or bypass from the dredge into the channel will not be allowed.

13. The use of a drag beam or similar piece of equipment to knock down high spots or ridges in the channel bottom will be prohibited.

14. The Corps will participate in a joint onsite inspection with NMFS upon the completion of maintenance dredging and bank protection activities in order to review project effects to essential fish habitat.

1.3.5 Interrelated and Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). No interrelated or interdependent activities have been identified for this project. Although the proposed project will maintain both the Sacramento and Stockton DWSC as commercial shipping lanes, no increase in the number of commercial vessel transits per day or vessel size is anticipated in the Sacramento and Stockton DWSC for the foreseeable future, and shipping impacts are therefore considered only as part of the environmental baseline.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for the purposes of this opinion includes portions of both the Sacramento and Stockton DWSC in the Delta where water levels are influenced by tributary inflows and tidal action. The action area is situated across portions of Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties, as described in further detail below.

In the Sacramento River, the action area includes the Sacramento DWSC from Collinsville to the City of West Sacramento, including portions of Suisun Bay, Montezuma Slough, Horseshoe Bend, Three Mile Slough, Steamboat Slough, Cache Slough, Miner Slough, Prospect Slough, Babel Slough, and the Port of West Sacramento. The Sacramento DWSC varies in width from 200 to 400 feet before it terminates at the Port of West Sacramento turning basin which is triangularly shaped, 3,100 feet long, and 1,800 feet wide at its widest point.

In the San Joaquin River, the action area includes the Stockton DWSC from the upstream end of New York Slough to the City of Stockton, including portions of Suisun Bay, Sacramento River, Montezuma Slough, New York Slough, Middle Slough, Broad Slough, Cabin Slough, Mayberry Slough, Dutch Slough, Gallagher Slough, False River, Three Mile Slough, Fisherman's Cut, Seven Mile Slough, Mokelumne River, Potato Slough, Old River, Little Connection Slough, Whiskey Slough, Disappointment Slough, Turner Cut, Fourteen Mile Slough, Buckley Cove, Burns Cutoff, Calaveras River, Smith Canal, and the Port of Stockton. The Stockton DWSC varies in width from 200 to 600 feet before it terminates at the Port of Stockton turning basin, which is 970 feet wide.

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

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

2.1 Analytical Approach

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

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

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.

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

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

2.2 Rangewide Status of the Species and Critical Habitat

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

The designations of critical habitat for each species uses 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 "destructive or adverse modification" analysis, which is the same regardless of whether the original designation identified PCE, physical or biological features, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

- First listed as threatened (August 4,1989, 54 FR 32085), reclassified as endangered (January 4, 1994, 59 FR 440), reaffirmed as endangered (June 28, 2005, 70 FR 37160 and August 15, 2011, 76 FR 50447)
- Designated critical habitat (June 16, 1993, 58 FR 33212)

A. Species Listing and Critical Habitat History

The Sacramento River winter-run Chinook salmon (winter-run, *Oncorhynchus tshawytscha*) ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085), and formally listed as a threatened species in November 1990 (55 FR 46515). On January 4, 1994, NMFS re-classified winter-run as an endangered species (59 FR 440). NMFS concluded that winter-run in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run (August 15, 2011, 76 FR 50447).

On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of five Pacific salmon ESUs, including the winter-run ESU, and determined that the species' status should again remain as "endangered" (August 15, 2011, 76 FR 50447). The 2011 review concluded that although the listing remained unchanged since the 2005 review, the status of the population had declined over the past 5 years (2005–2010).

The winter-run ESU currently consists of only one population that is confined to the upper Sacramento River (spawning below Shasta and Keswick dams) in California's Central Valley. In addition, an artificial propagation program at the Livingston Stone National Fish Hatchery (LSNFH) produces winter-run that are considered to be part of this ESU (June 28, 2005, 70 FR 37160). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Remaining spawning and rearing areas are completely dependent on cold water releases from Shasta Dam in order to sustain the remnant population.

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

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

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

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

1. Adult Migration Corridors

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

2. Spawning Habitat

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

3. Adequate River Flows

Adequate River flows are defined as providing "adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles." An April 5, 1960, Memorandum of Agreement between Reclamation and the California Department of Fish and Game[2] originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in State Water Resource Control Board (SWRCB) Water Rights Order (WRO) 90-05 for the protection of Chinook salmon. This order includes a

[2] The agency changed its name in 2013 to California Department of Fish and Wildlife.

minimum flow release of 3,250 cubic feet per second (cfs) from Keswick Dam downstream to RBDD from September through February during all water year types, except critically dry.

4. Water Temperatures

Optimum water temperatures for successful spawning, egg incubation, and fry development range from 6–10°C (42.8–50°F). Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of winter-run migration, spawning, egg incubation, fry development, and emergence. This pattern, the opposite of the pre-dam hydrograph, benefits winter-run by providing cold water for miles downstream during the hottest part of the year. The extent to which winter-run habitat needs are met depends on Reclamation's other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir end of September storage levels required in the NMFS 2009 biological opinion on the long-term operations of the Central Valley Project and State Water Project (CVP/SWP, NMFS 2009a). WRO 90-05 and 91-1 require Reclamation to operate Shasta, Keswick, and Spring Creek Powerhouse to meet a daily average water temperature of 13.3°C (56°F) at RBDD. They also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. Based on these requirements, Reclamation models monthly forecasts and determines how far downstream 13.3°C (56°F) can be maintained throughout the winter-run spawning, egg incubation, and fry development stages.

In every year since WRO 90-05 and 91-1 were issued, operation plans have included modifying the TCP location of 56°F daily average temperature to make the best use of the cold water available based on water temperature modeling, current spawning distribution, and Reclamation's other operational commitments including those to water contractors, D-1641 regulations and criteria, and projected end of September storage volume. Water temperatures are typically adequate through the summer for successful winter-run egg incubation and fry development for those redds constructed upstream of the TCP (except for in some critically dry and drought years). However, by continually moving the TCP upstream, the value of that habitat is degraded by reducing the spawning area in size and imprinting upon the next generation to return further upstream.

5. Habitat and Adequate Prey Free of Contaminants

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

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

6. <u>Riparian and Floodplain Habitat</u>

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

7. <u>Juvenile Emigration Corridors</u>

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

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

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

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

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

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

C. Life History

1. Adult Migration and Spawning

Winter-run exhibit a unique life history pattern (Healey 1994) compared to other salmon populations in the Central Valley (*i.e.*, spring-run, fall-run, and late-fall run), in that they spawn in the summer, and the juveniles are the first to enter the ocean the following winter and spring. Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the RBDD from mid-December through early August (National Marine Fisheries Service 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type.

Winter-run tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (Healey 1991). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run deposit and fertilize eggs in gravel beds known as redds excavated by the female that then dies following spawning. Average fecundity was 5,192 eggs/female for the 2006–2013 returns to LSNFH, which is similar to other Chinook salmon runs [*e.g.*, 5,401 average for Pacific Northwest (Quinn 2005)]. Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature is between 55–57°F (13–14°C) (Snider *et al.* 2001). The majority of winter-run adults return as 3-year olds.

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

Winter-run incubating eggs are vulnerable to adverse effects from floods, flow fluctuations, siltation, desiccation, disease, predation during spawning, poor gravel percolation, and poor water quality. The optimal water temperature for egg incubation ranges from 46–56°F (7.8–13.3°C) and a significant reduction in egg viability occurs in mean daily water temperatures above 57.5°F (14.2°C) (Seymour 1956, Boles 1988, U.S. Fish and Wildlife Service 1998, U.S. Environmental Protection Agency 2003, Richter and Kolmes 2005, Geist *et al.* 2006). Total embryo mortality can occur at temperatures above 62°F (16.7°C); (National Marine Fisheries Service 1997). Depending on ambient water temperature, embryos hatch within 40-60 days and alevin (yolk-sac fry) remain in the gravel beds for an additional 4–6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding in their natal stream, typically in late July to early August and continuing through October (Fisher 1994).

3. <u>Juvenile Rearing and Outmigration</u>

Juvenile winter-run have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman *et al.* 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only 4 to 7 months of river life, while others hold and rear upstream and spend 9 to 10 months in freshwater. Emigration of juvenile winter-run fry and pre-smolts past RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September, and can continue through March in dry years (Vogel and Marine 1991, National Marine Fisheries Service 1997).

4. <u>Estuarine/Delta Rearing</u>

Juvenile winter-run emigration into the Delta and estuary occurs primarily from November through early May based on data collected from trawls in the Sacramento River at Sherwood Harbor (West Sacramento), RM 57 (U.S. Fish and Wildlife Service 2001). The timing of emigration may vary somewhat due to changes in river flows, Shasta Dam operations, and water year type, but has been correlated with the first storm event when flows exceed 14,000 cfs at Knights Landing, RM 90, which trigger abrupt emigration towards the Delta (del Rosario *et al.* 2013). The average residence time in the Delta for juvenile winter-run is approximately 3 months based on median seasonal catch between Knights Landing and Chipps Island. In general, the earlier juvenile winter-run enter the Delta, the longer they stay and rear. Peak departure at Chipps Island regularly occurs in March (del Rosario *et al.* 2013). The Delta serves as an important rearing and transition zone for juvenile winter-run as they feed and physiologically adapt to marine waters during the smoltification process (change from freshwater to saltwater). The majority of juvenile winter-run in the Delta are 104 to 128 millimeters (mm) in size based on U.S. Fish and Wildlife Service (USFWS) trawl data (1995-2012), and from 5 to 10 months of age, by the time they depart the Delta (Fisher 1994, Myers *et al.* 1998).

5. Ocean Rearing

Winter-run smolts enter the Pacific Ocean mainly in spring (March–April), and grow rapidly on a diet of small fishes, crustaceans, and squid. Salmon runs that migrate to sea at a larger size tend to have higher marine survival rates (Quinn 2005). The diet composition of Chinook salmon from California consist of anchovy, rockfish, herring, and other invertebrates (Healey 1991). Most Chinook from the Central Valley move northward into Oregon and Washington, where herring make up the majority of their diet. Upon entering the ocean, however, winter-run tend to stay near the California coast and distribute from Point Arena southward to Monterey Bay. Winter-run have high metabolic rates, feed heavily, and grow fast compared to other fishes in their range. They can double their length and increase their weight more than ten-fold in the first summer at sea (Quinn 2005). Mortality is typically highest in the first summer at sea, but can depend on ocean conditions. Winter-run abundance has been correlated with ocean conditions such as periods of strong up-welling, cooler temperatures, and El Nino events (Lindley *et al.* 2009c). Winter-run spend approximately 1-2 years rearing in the ocean before returning to the Sacramento River as 2-3 year old adults. Very few winter-run Chinook salmon reach age 4. Once they reach age 3 they are large enough to become vulnerable to commercial and sport fisheries.

D. Description of Viable Salmonid Population (VSP) Parameters

1. Abundance

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011c). Since carcass surveys began in 2001 the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. From 2007 to 2013, however, the population declined precipitously, averaging 2,486 during this period with a low of 827 adults in 2011. This recent declining trend was likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009c), persistent drought conditions, and low in-river survival (National Marine Fisheries Service 2011c). In 2014 and 2015, the population was 3,015 and 3,440 adults, respectively, slightly above the 2007–2012 average, but well below the high (17,296) for the last 10-year period.

Although impacts from hatchery fish (*i.e.*, reduced fitness, weaker genetics, smaller size, diminished ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the winter-run conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at

LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes RBDD, which is 4.7 million per year based on the 2002–2010 average (Poytress and Carrillo 2011). Hatchery production therefore typically represents approximately 3-4 percent of the total in-river juvenile production in any given year.

2014 was the third year of a drought which increased water temperatures in the upper Sacramento River causing significantly higher mortality (95-97%) in the upper spawning area. Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled to offset the impact of the drought. In 2014, hatchery production represented approximately 50-60% of the total in-river juvenile production. Drought conditions persisted through 2015 and hatchery production was increased again to approximately 420,000 fish released, representing more than 50% of the total naturally produced run size.

2. Productivity

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggested a reduction in productivity and indicated that the winter-run population was not replacing itself. For the last three consecutive years (2013-2015) however, the winter-run population has experienced a positive CRR, possibly due to more favorable in-river conditions resulting in increased juvenile survival to the ocean.

An age-structured density-independent model of spawning escapement by (Botsford and Brittnacher 1998) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females (Good *et al.* 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures and found a biologically significant expected quasi-extinction probability of 28 percent. Although the growth rate for the winter-run population improved up until 2006, it exhibits the typical variability found in most endangered species populations. The fact that there is only one population dependent upon cold-water releases from Shasta Dam makes it vulnerable to periods of prolonged drought (National Marine Fisheries Service 2011c). Productivity, as measured by the number of juveniles entering the Delta, or juvenile production estimate (JPE), has declined in recent years from a high of 3.8 million in 2007 to 124,521 in 2014. Due to uncertainties in the various JPE factors, it was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences model), and again in 2013-2015 with a change in survival based on acoustic tag data (National Marine Fisheries Service 2016). However, juvenile winter-run productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

3. Spatial Structure

The distribution of winter-run spawning and initial rearing historically was limited to the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963) (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 (NFH) weir]. The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, which should restore spawning and rearing habitat for winter-run in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam remains inaccessible to winter-run. Yoshiyama *et al.* (2001) estimated that in 1938, the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for winter-run lies within its spatial structure (National Marine Fisheries Service 2011c). The remnant and remaining population cannot access 95 percent of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and, (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures. Winter-run require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2017. The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam.

4. Diversity

The current winter-run population is the result of the introgression of several stocks (*e.g.*, spring-run and fall-run Chinook) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007) recommended reclassifying the winter-run population extinction risk from low to moderate if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 1996, the percentage of hatchery winter-run recovered in the Sacramento River has only been above 15 percent four times; in 2005, 2012, and 2014-2015.

Concern over genetic introgression within the winter-run population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run have made up more than 5 percent of the natural spawning run in recent years, and in 2012 it exceeded 30 percent of the natural run. However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley *et al.* (2007).

5. Summary of ESU Viability

There are several criteria (only one is required) that would qualify the winter-run ESU at moderate risk of extinction, and since there is still only one population that spawns below Keswick Dam, that population would be at high risk of extinction in the long-term according to the criteria in (Lindley *et al.* 2007). Recent trends in those criteria are: (1) continued low abundance; (2) a negative growth rate over 6 years (2006–2012), which is two complete generations; (3) a significant rate of decline since 2006; and (4) an increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change). The most recent 5-year status review (National Marine Fisheries Service 2011c) on winter-run concluded that the ESU had reached a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the winter-run ESU has increased from a moderate to a high risk of extinction since 2005 (last review), and that several listing factors have contributed to the recent decline including pervasive drought and poor ocean conditions (National Marine Fisheries Service 2011c).

2.2.2 Central Valley spring-run Chinook salmon Evolutionarily Significant Unit (ESU)

- First listed as threatened (September 16, 1999, 64 FR 50394), reaffirmed as threatened (June 28, 2005, 70 FR 37160 and August 15, 2011, 76 FR 50447)
- designated critical habitat (September 2, 2005, 70 FR 52488)

A. Species Listing and Critical Habitat History

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

In August 2011, NMFS completed an updated status review of five Pacific Salmon ESUs, including CV spring-run, and concluded that the species' status should remain as previously listed (76 FR 50447). The 2011 Status Review (NMFS 2011) additionally stated that although the listings will remain unchanged since the 2005 review, and the original 1999 listing (64 FR

50394), the status of these populations has worsened over the past 5 years and recommended that the status be reassessed in 2 to 3 years, as opposed to waiting another 5 years.

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

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

1. Spawning Habitat

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

2. Freshwater Rearing Habitat

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

3. Freshwater Migration Corridors

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

4. Estuarine Areas

Estuarine areas, such as the San Francisco Bay and the downstream portions of the Sacramento-San Joaquin Delta, free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PBF. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging.

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

C. Life History

1. Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run leave the ocean to begin their upstream migration in late January and early February (California Department of Fish and Game 1998) and enter the Sacramento River beginning in March (Yoshiyama *et al.* 1998). Spring-run Chinook salmon move into tributaries of the Sacramento River (*e.g.*, Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley *et al.* 2004, see Table I in text). Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 3ºC (38ºF) to 13ºC (56ºF) (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 18ºC (65ºF) for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 21ºC (70ºF), and that fish can become stressed as temperatures approach 21ºC (70ºF). Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 15.6 ºC (60ºF); although salmon can tolerate temperatures up to 18 ºC (65ºF) before they experience an increased susceptibility to disease (Williams 2006).

2. Adult Spawning

Spring-run Chinook salmon spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994); spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

Spring-run Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995, NMFS 2007). Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad, velocities typically ranging from1.2 feet/second to 3.5 feet/second, and water depths greater than 0.5 feet (YCWA *et al.* 2007). The upper preferred water temperature for spawning Chinook salmon is 13 ºC to 14 ºC (55ºF to 57ºF) (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, CDFG 2001). Chinook salmon are semelparous (die after spawning).

3. Eggs and Fry Incubation to Emergence

The CV spring-run embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sac prior to emergence. The length of time for CV spring-run embryos to develop depends largely on water temperatures. In well-oxygenated intergravel environs where water temperatures range from about 5 to 13ºC (41 to 55.4ºF) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2014). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence conducted by Shelton (1955) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 5 ºC to 14 ºC (41ºF to 56ºF) (National Marine Fisheries Service 1997, Moyle 2002). A significant reduction in egg viability occurs at water temperatures above 14 ºC (57.5ºF) and total embryo mortality can occur at temperatures above 17 ºC (62ºF) (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16ºC and 3ºC (61ºF and 37ºF), respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4- to 6-week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The newly emerged fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 millimeters (mm) to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

4. Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of development (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. The daily migration of juveniles passing RBDD is highest in the 4-hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found that Chinook salmon fry may travel as far as 30 km per day in the Sacramento River. As Chinook salmon begin the smolt stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of CV spring-run migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). The California Department of Fish and Game (1998) observed the emigration period for spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, CDFG 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 12ºC to 14 ºC (54ºF to 57ºF) (Brett 1952).

5. Estuarine Rearing

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings *et al.* 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean.

6. Ocean Rearing

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California Current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002, Lindley *et al.* 2009a). After entering the ocean, juveniles become voracious predators on small fish and crustaceans, and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic plankton is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The ocean stage of the Chinook life cycle lasts 1 to 5 years. Information on salmon abundance and distribution in the ocean is based upon CWT recoveries from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns.

Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement (adult spawner populations that have "escaped" the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

D. Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the CV spring-run ESU, and determine the extinction risk of the ESU, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany *et al.* 2000b)

1. <u>Abundance</u>

Historically 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 spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy, for the hatchery program. On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (California Department of Water Resources 2001). However, after 1981, CDFG ceased to estimate in-river spawning spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. Spring-run Chinook salmon estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,783 fish in 2011 (CDFW Grandtab 2013). Genetic testing has indicated that substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (CDWR 2001). Because Chinook salmon have not always been spatially separated in the FRFH, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock (CDFW and CDWR 2012, Good *et al.* 2005). In addition, coded-wire tag (CWT) information from these hatchery returns has indicated that fall-run and spring-run Chinook salmon have overlapped

(CDWR 2001). For the reasons discussed above, the FRFH spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon has made identification of spring-run Chinook salmon in the mainstem very difficult to determine, and there is speculation as to whether a true spring-run Chinook salmon population still exists in the Sacramento River downstream of Keswick Dam. Although the physical habitat conditions downstream of Keswick Dam are capable of supporting spring-run Chinook salmon, higher than normal water temperatures in some years have led to substantial levels of egg mortality. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; 2012 observed 0 redds, and 2013, 57 redds in September (CDFW, unpublished data, 2013). This is typically when spring-run Chinook salmon spawn, however, these redds also could be early spawning fall-run Chinook salmon. Therefore, even though physical habitat conditions may be suitable for spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998. Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000 (although 2008 was nearly 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005 the CV spring-run ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates displayed a high level of fluctuation, and the overall number of CV spring-run remained well below estimates of historic abundance.

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

From 2005 through 2011, abundance in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011 placed the Mill and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 and 2015 exhibited a progressively declining trend, with slightly less than 10,000 and just over 5,000 fish returning in those successive years, respectively, which indicates a highly fluctuating and unstable ESU abundance.

2. Productivity

The productivity of a population (*i.e.*, production over the entire life cycle) can reflect environmental conditions that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000b). In general, declining productivity equates to declining population abundance. McElhany *et al.* (2000b) suggested criteria for a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation.

From 1993 to 2007 the 5-year moving average of the tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011. The productivity of the Feather and Yuba river populations and contribution to the CV spring-run ESU currently is unknown, however the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive (1.85). However, 2015 returns were very low, with a CRR of 0.14, when using Butte Creek snorkel survey numbers, the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02.

3. Spatial Structure

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek and Beegum Creek (tributary to Cottonwood Creek), that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2013 unpublished data).

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

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

A final rule was published to designate a nonessential experimental population of CV spring-run to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the San Joaquin River Restoration Project (SJRRP) (78 FR 251; December 31, 2013). Pursuant to ESA section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking CV spring-run within the experimental population area, and in specific instances elsewhere. The first release of CV spring-run juveniles into the San Joaquin River occurred in April, 2014. A second release occurred in 2015, and future releases are planned to continue annually during the spring. The SJRRP's future long-term contribution to the CV spring-run ESU has yet to be determined.

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus River since 2003 and on the Tuolumne River since 2009, has indicated upstream migration of adult spring-run Chinook salmon, and 114 adults were counted on the video weir on the Stanislaus River from February to June in 2013 with only 7 individuals without adipose fins (FishBio 2015).. Finally, rotary screw trap (RST) data provided by Stockton U.S. Fish and Wildlife Service (USFWS) corroborates the spring-run Chinook salmon adult timing by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration (Franks 2014). Although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams. Genetic assessment or natal stream analyses of hard tissues could inform our understanding of the relationship of these fish to the ESU.

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

4. Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics (including rate of gene-flow among populations). Criteria for the diversity parameter are that human-caused factors should not alter variation of traits. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000b). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The CV spring-run 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. The Feather River spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon, and it appears that the Yuba River spring-run Chinook salmon population may have been impacted by FRFH fish straying into the Yuba River (and likely introgression with wild Yuba River fall-run has also occurred). Additionally, the diversity of the spring-run Chinook salmon ESU has been further reduced with the loss of the majority, if not all, of the San Joaquin River basin spring-run Chinook salmon populations. Efforts underway like the San Joaquin River Restoration Project (to reintroduce a spring-run population below Friant Dam) are needed to improve the diversity of CV spring-run.

5. Summary of ESU Viability

Since the populations in Butte, Deer, and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Lindley *et al.* (2007) indicated that the spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at a moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run ESU failed to meet the “representation and redundancy rule” since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them, or out of the four diversity groups as described in the NMFS Central Valley Salmon and Steelhead Recovery Plan. Over the long term, these three remaining populations are considered to be vulnerable to catastrophic events such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Until 2012, the status of CV spring-run ESU had deteriorated on balance since the 2005 status review and the Lindley *et al.* (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams *et al.* 2011). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

The viability assessment of CV spring-run 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 recommended that its status be reassessed in two to three years as opposed to waiting another five years if the decreasing trend continues and the ESU does not respond positively to improvements in environmental conditions and management actions. In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review was conducted in 2015 (NMFS 2016), which looked at promising increasing populations in 2012-2014, however the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality resulting in record low spawning. Since the effects of the 2012-2015 drought have not been fully realized, we anticipate at least several more years of very low returns, which may reach catastrophic rates of decline.

2.2.3 California Central Valley Steelhead distinct population segment (DPS)

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

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

A. Species Listing and Critical Habitat Designation History

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good *et al.* 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the Feather River Hatchery and Coleman NFH stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 west coast salmonid ESUs and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR 834). On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488).

B. Critical Habitat and Physical or Biological Features (PBFs) for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta. Currently the CCV steelhead DPS and critical habitat extends up the San Joaquin River up to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain) (Bain and Stevenson 1999, 70 FR 52488). Critical habitat for CCV steelhead is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PBFs for CCV steelhead.

1. <u>Spawning Habitat</u>

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, egg incubation, and larval development. Most of the available spawning habitat for steelhead in the Central Valley is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have negative effects upon salmonids spawning and rearing below the dams. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

2. <u>Freshwater Rearing Habitat</u>

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

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream and downstream passage of adults, and the emigration of smolts. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value even if the migration corridors are significantly degraded compared to their natural state.

4. Estuarine Areas

Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PBF. Natural cover such as submerged and overhanging LWM, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment.

C. Life History

1. Egg to Parr

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in three to four weeks at 10°C (50°F) to 15°C (59°F) (Moyle 2002). After hatching, alevins remain in the gravel for an additional two to five weeks while absorbing their yolk sacs, and emerge in spring or early summer (Barnhart 1986). Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986, NMFS 1996).

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

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or boulders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 15°C (59°F) to 20°C (68°F) (McCullough *et al.* 2001, Spina 2006). Cherry *et al.* (1975 *op. cit*. Myrick and Cech 2001) found preferred temperatures for rainbow trout ranged from 11°C (51.8°F) to 21°C (69.8°F) depending on acclimation temperatures.

2. <u>Smolt Migration</u>

Juvenile steelhead will often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch *et al.* 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage in the California Central Valley.

3. <u>Ocean Behavior</u>

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that California steelhead may not migrate to the Gulf of Alaska region of the north Pacific as commonly as more northern populations such as those in Washington and British Colombia. (Burgner 1993)) reported that no CWTed steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of Central Valley steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

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

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

4. Spawning

CCV steelhead generally enter freshwater from August to November with a peak in September (Hallock *et al.* 1961), and spawn from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Williams 2006, Hallock *et al.* 1961, McEwan and Jackson 1996). The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman *et al.* 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F daily average water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern as this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

Few direct counts of fecundity are available for CCV steelhead populations, but since the number of eggs laid per female is highly correlated with adult size, adult size can be used to estimate fecundity with reasonable precision. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after one or two years at sea (Hallock *et al.* 1961), and adults typically range in size from two to twelve pounds (Reynolds *et al.* 1993). Steelhead about 55 cm (FL) long may have fewer than 2,000 eggs, whereas steelhead 85 cm (FL) long can have 5,000 to 10,000 eggs depending on the stock (Meehan and Bjornn 1991). The average for Coleman NFH since 1999 is about 3,900 eggs per female (USFWS 2011).

Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek. Null *et al.* (2013) found between 36 percent and 48 percent of kelts released from Coleman NFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman NFH in the 1971 season when only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider *et al.* 1986).

5. Kelts

Post-spawning steelhead (kelts) may migrate downstream to the ocean immediately after spawning, or they may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Recent studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo *et al.* 2011), but that most return to the ocean (Null *et al.* 2013).

D. Description of Viable Salmonid Population (VSP) Parameters

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

1. Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers *et al.* 2010).

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

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

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

Steelhead returns to Coleman NFH have fluctuated greatly over the years. From 2003 to 2012, the number of hatchery origin adults has ranged from 624 to 2,968. Since 2003 adults returning to the hatchery have been classified as either wild (unclipped) or hatchery produced (adipose clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200-500 fish each year.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 151 redds have been counted in Clear Creek from 2001 to 2010 (data from USFWS), and an average of 154 redds have been counted on the American River from 2002-2010 (data from Hannon and Deason 2008, Hannon *et al.* 2003, Chase 2010).

The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season, and the overall trend is a slight increase. However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite *et al.* 2010), which are not part of the CCV steelhead DPS.

The returns of steelhead to the Feather River Hatchery have decreased greatly over time with only 679, 312, and 86 fish returning in 2008, 2009, and 2010, respectively. This is despite the fact that almost all of these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. However, preliminary return data for 2011 (CDFW) shows a slight rebound in numbers, with 712 adults returning to the hatchery through April 5, 2011.

The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001. The average redd index from 2001 to 2011 is 157, representing somewhere between 128 and 255 spawning adult steelhead on average each year. The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the proportion of wild steelhead relative to hatchery steelhead (CDFW; ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993, however. The percentage of unclipped steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

The years 2009 and 2010 showed poor returns of steelhead to the FRFH and Coleman NFH, probably due to three consecutive drought years in 2007-2009, which would have impacted parr and smolt growth and survival in the rivers, and possibly due to poor coastal upwelling conditions in 2005 and 2006, which strongly impacted fall-run Chinook salmon post-smolt survival (Lindley *et al.* 2009b). Wild (unclipped) adult counts appear not to have decreased as greatly in those same years, based on returns to the hatcheries and redd counts conducted on Clear Creek, and the American and Mokelumne rivers. This may reflect greater fitness of naturally produced steelhead relative to hatchery fish, and certainly merits further study.

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2011 that no clear trend is present other than the fact that the numbers are still far below those seen in the 1960's and 1970's, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns.

2. Productivity

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams *et al.* 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl dataset from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Good *et al.* (2005) made the following conclusion based on the Chipps Island data:

> *"If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".*

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite *et al.* (2010), it is likely that most of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). However, this practice was discontinued for Nimbus stock after 1991 and discontinued for Feather River stock after 2008. Recent genetic studies show that the Mokelumne River Hatchery steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock.

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

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

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

3. Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley *et al.* 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama *et al.* 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005; NMFS 2011). Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer Fish Sciences 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO 2012, 2013a). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012 when a total of 381 were caught (FISHBIO 2013c). The unusually high number of *O. mykiss* captured may be attributable to a flashy storm event that rapidly increased flows over a 24 hour period. Annual Kodiak trawl surveys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

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

4. <u>Diversity</u>

a. Genetic Diversity: 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 also supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among Central Valley steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

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

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

> *"Between 1944 and 1947, annual counts of summer-run steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish. After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead were no longer able to access their historic spawning areas, and perished in the warm water downstream of Old Folsom Dam."* (Gerstung 1971)

Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002; McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CV streams, presently located above impassible dams (Lindley *et al.* 2006).

Juvenile steelhead (parr) rear in freshwater for one to three years before migrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater is inversely related to their growth rate, with faster-growing members of a cohort smolting at an earlier age but a smaller size (Peven *et al.* 1994, Seelbach 1993). Hallock *et al.* (1961) aged 100 adult steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954, and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most steelhead return to their natal streams as adults at a total age of two to four years (Hallock *et al.* 1961, McEwan and Jackson 1996).

Deer and Mill creeks were monitored from 1994 to 2010 by the CDFW using rotary screw traps to capture emigrating juvenile steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill creeks, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm in Deer and Mill creeks, while smolts averaged 210 mm and 204 mm. Most silvery parr and smolts were caught in the spring months from March through May, while fry and parr peaked later in the spring (May and June) and were fairly common in the fall (October through December) as well.

In contrast to the upper Sacramento River tributaries, Lower American River juvenile steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolt at age-1 (Sogard *et al.* 2012).

5. Summary of ESU Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005; NMFS 2011); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock. Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

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

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

The most recent status review of the CCV steelhead DPS (NMFS 2011) found that the status of the population appears to have worsened since the 2005 status review (Good *et al.* 2005), when it was considered to be in danger of extinction.

2.2.4 Southern Distinct Population Segment (DPS) of North American Green Sturgeon (*Acipenser medirostris*)

- Listed as threatened on June 6, 2006 (71 FR 17757)
- Critical habitat designated October 9, 2009 (74 FR 52300)

A. Species Listing and Critical Habitat History

Green sturgeon (*Acipenser medirostris*) are a species of ancient fish, highly adapted to benthic environments, and very marine oriented entering freshwater mainly to spawn, but residing in bays, estuaries, and near coastal marine environments for the vast majority of their lifespan. They are known to be long lived; green sturgeon captured in Oregon have been age-estimated up to 52 years old using a fin-spine analysis (Farr and Kern 2005). They are iteroparous, meaning they can spawn multiple times within their lifespan. The details of their biology are described in the life history section of this document, and also in various literature sources such as Moyle (2002), (Adams *et al.* 2007), (Beamesderfer *et al.* 2007), and (Israel and Klimley 2008).

Green sturgeon are broken into two distinct population segments (DPSs), a northern DPS and a southern DPS (sDPS), and while individuals from the two DPSs are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed, nor do they utilize the spawning areas of each other's natal rivers. In this document we are concerned primarily with sDPS green sturgeon because of its status as a listed species under the ESA. The sDPS green sturgeon include those green sturgeon that spawn south of the Eel River, specifically within the Sacramento and Feather rivers and possibly also the Yuba River. In this document we review the life history of sDPS green sturgeon, discuss population viability parameters, identify extinction risk, discuss critical habitat features and their conservation values, and we discuss the suite of factors affecting the species. When necessary to fill in knowledge gaps we borrow information about white sturgeon (*A. transmontanus*) and other sturgeon species, keeping the reader informed of this cross-species informational exchange.

In June of 2001, NMFS received a petition to list green sturgeon under the ESA and to designate critical habitat. After completion of a status review (Adams *et al.* 2002), NMFS found that the species was comprised of two DPS's that qualify as species under the ESA, but that neither DPS warranted listing. In 2003 this "not warranted' decision was challenged in federal court, and NMFS was asked to reconsider available information, taking into account rapidly developing new information. NMFS (2005) revised its "not warranted" decision and proposed to list the sDPS as "threatened." In its 2006 final decision to list sDPS green sturgeon as threatened, NMFS cited concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats with regard to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities (71 FR 17757). Since the original 2006 listing decision, new information has become available that reinforces the original reasons for listing and reaffirms NMFS concerns that sDPS green sturgeon face substantial threats challenging their recovery.

B. Critical Habitat and Physical or Biological Features (PBF) for sDPS green sturgeon

NMFS designated critical habitat for sDPS green sturgeon on October 9, 2009 by authority of Section 4(b) of the ESA. Out of 41 habitat units considered, 14 units were excluded from designation as critical habitat because the economic benefit of exclusion outweighed the conservation benefits of designation, and these exclusions would not significantly impede the conservation of the species (74 FR 52300). Briefly, critical habitat for sDPS green sturgeon includes, (1) the Sacramento River from the I-Street Bridge to Keswick Dam, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge, (2) the Feather River up to the Fish Barrier Dam, (3) the Yuba River up to Daguerre Point Dam, (4) the Sacramento-San Joaquin Delta (as defined by California Water Code section 12220), but with many exclusions (see 74 FR 52300), (5) San Francisco Bay, San Pablo Bay, and Suisun Bay, but with many exclusions, and (6) coastal marine areas to the 60 fathom depth bathymetry line from Monterey Bay, California to the Strait of Juan de Fuca, Washington.

Critical habitat for sDPS green sturgeon is defined as specific areas that contain the primary PBFs and physical habitat elements essential to the conservation of the species. Following are the PBFs for sDPS green sturgeon for the freshwater and estuarine systems of the Central Valley of California (74 FR 52300).

The specific PBFs in freshwater riverine systems include:

1. <u>Food Resources</u>

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

2. <u>Substrate Type or Size</u>

Substrate type consists of pockets of sand and gravel (2.0 to 64.0 millimeters (mm) in size) within the crevices of larger substrate, such as cobble and boulders ((Poytress *et al.* 2011). Eggs are likely to adhere to sand and gravel after settling into crevices between larger substrates (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Larvae utilize benthic structure (Van Eenennaam *et al.* 2001, Deng *et al.* 2002, Kynard *et al.* 2005) and seek refuge within crevices, but will forage over hard surfaces (Nguyen and Crocker 2006).

3. <u>Water Flow</u>

Water flow regimes consist of stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (14 – 17.5°C) ((Mayfield and Cech 2004, Van Eenennaam *et al.* 2005, Allen *et al.* 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about

14,000 cfs [average daily flows during spawning months range from 6,900 – 10,800 cfs; Brown (2007)]. In Oregon's Rogue River, green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 10° C and flows increased (Erickson *et al.* 2002). On the Klamath River, the fall outmigration of green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al.* 2007). On the Sacramento River flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

4. Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen levels are discussed in detail in the life history section.

5. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. This PBF is highly degraded compared to its historical condition due to man-made barriers and alteration of habitat. Keswick Dam, at river mile (RM) 302, forms a complete barrier to any potential sturgeon migration on the Sacramento River, but downstream of this point good spawning and rearing habitat exists primarily in the river reach between Keswick Dam and RBDD (RM 242). The Feather River and Yuba River also offer potential green sturgeon spawning habitat, but those rivers contain their own man-made barriers to migration and are highly altered environments.

6. Depth

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

7. Sediment Quality

Sediment should be of the appropriate quality and characteristics necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants [*e.g.*, elevated levels of heavy metals (*e.g.*, mercury, copper, zinc, cadmium, and chromium), PAHs, and organochlorine pesticides] that can result in negative effects on any life stage of green sturgeon or their prey. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of green sturgeon.

The specific PBFs in estuarine areas include:

1. <u>Food Resources</u>

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PBF for green sturgeon. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within bays and estuaries.

2. <u>Water Flow</u>

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the Bay and to initiate upstream spawning migrations.

3. <u>Water Quality</u>

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen necessary for green sturgeon are discussed in detail in the life history section.

4. <u>Migratory Corridor</u>

Safe and unobstructed migratory pathways are necessary for the successful and timely passage of adult, sub-adult, and juvenile fish within estuarine habitats and between estuarine and riverine or marine habitats. Fish need the ability to freely migrate from the river through the estuarine waterways of the Delta and bays and eventually out into the ocean. Southern DPS green sturgeon use the Sacramento River and the Sacramento-San Joaquin Delta as a migratory corridor. Additionally, certain bays and estuaries throughout Oregon and Washington and into Canada are also utilized for rearing and holding, and these areas too must offer safe and unobstructed migratory corridors.

One of the key areas of concern is the Yolo and Sutter bypasses. These leveed floodplains are engineered to convey floodwaters of the greater Sacramento Valley and they include several concrete weir structures that allow flood flows to escape into the bypass channels. Adult sturgeon are attracted into the bypasses by these high flows. However the weirs can act as barriers and block the passage of fish. Fish can also be trapped in the bypasses as floodwaters recede (USFWS 1995, DWR 2005). Some of the weir structures have been designed with fish ladders to provide upstream adult salmon passage but these ladders have shown to be ineffective for providing upstream passage to adult sturgeon (DWR and Reclamation 2012). In addition there are irregularities in the splash basins at the foot of these weirs and multiple road crossings and agricultural impoundments in the bypasses that block hydraulic connectivity and can impede fish passage. As a result sturgeon may become stranded in the bypasses and face delayed migration and lethal and sub-lethal effects from poaching, high water temperatures, low dissolved oxygen, and desiccation.

5. Water Depth

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy deep (more than 5 m) holding pools within bays, estuaries, and freshwater rivers. These deep holding pools may be important for feeding and energy conservation, or may serve as thermal refugia (Benson *et al.* 2007). Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters with depths of less than 10 meters, either swimming near the surface or foraging along the bottom (Kelly *et al.* 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3 - 8 feet deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966).

6. Sediment Quality

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

Coastal Marine Areas

The PBFs for coastal marine areas are omitted from this document as the focus here is upon the California Central Valley and the Sacramento-San Joaquin Bay Delta. A full description of all PBFs, including those for coastal marine areas, may be found in (74 FR 52300).

Critical Habitat Summary

The current condition of critical habitat for sDPS green sturgeon is degraded over its historical condition. In particular, migratory corridor and water flow PBFs have been particularly impacted by human actions, substantially altering the historical environmental characteristics in which sDPS green sturgeon evolved.

C. Green Sturgeon Life History

1. Adult Migration and Spawning

Green sturgeon reach sexual maturity between 15–17 years of age (Beamesderfer *et al.* 2007), and they typically spawn once every 2–5 years (average is 3.75 years) (Mora unpublished data). Based on data from acoustic tags (Heublein *et al.* 2009), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between January and early May. Migration through the bay/Delta takes about one week and progress upstream is fairly rapid to their spawning sites. Green sturgeon spawn primarily in the Sacramento River with most spawning activity concentrated in the mid-April to mid-June time period (Poytress *et al.* 2013). In 2011 spawning was confirmed in the Feather River by DWR, and suggested in the Yuba River by a report released by Cramer Fish Sciences (Bergman *et al.* 2011).

Various studies of spawning site characteristics (Poytress *et al.* 2011) agree that spawning sDPS green sturgeon typically favor deep, turbulent holes over 5 meters deep, featuring sandy, gravel, and cobble type substrates. Water depth may be negotiable, as spawning has been documented in depths as shallow as 2 meters (Poytress *et al.* 2011). However, substrate type is likely constrained as the interstices of the cobble and gravel catch and hold eggs, allowing them to incubate without being washed downstream. Flows need to be high enough to create the deep, turbulent habitat that green sturgeon favor for spawning. Successful egg development requires a water temperature range between 11°C and 19°C (52°F and 66°F). Larvae and juveniles appear to have broader temperature tolerances than eggs.

Poytress *et al.* (2012) conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 that identified a number of spawning locations. Green sturgeon fecundity is approximately 50,000–80,000 eggs per adult female (Van Eenennaam *et al.* 2001). Green sturgeon have the largest egg size of any sturgeon. The outside of the eggs are mildly adhesive and are denser than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009)

Post spawning adults have been observed to leave the system rapidly or to hold in deep pools and migrate downriver in winter after the first storms. Benson *et al.* (2007) conducted a study in which 49 adult green sturgeon were tagged with radio and/or sonic telemetry tags and tracked manually or with receiver arrays from 2002 to 2004. Tagged individuals exhibited four movement patterns: upstream spawning migration, spring outmigration to the ocean, or summer holding, and outmigration after summer holding. Following spawning sDPS green sturgeon typically re-enter the ocean generally from November through January (with the onset of the first winter storms), with migration through the estuary lasting about a week.

2. Juvenile Migration

Larval green sturgeon hatch in the late spring or summer (peak in July) and progress downstream towards the Delta rearing into juveniles. It is unknown when they enter the Delta, but it is widely believed that they may typically rear for up to 2–3 years before entering the ocean. Ocean entry marks the transition from juvenile to sub-adults.

3. Egg and Larval Stages

Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15° C (59° F) (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Studies conducted at the University of California, Davis (UC Davis) by Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14° C (57.2°F) and 17.5° C (62.6°F). Temperatures over 23 ° C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5° C (63.5°F) and 22° C (71.6°F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14° C (57.2°F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam *et al.* 2005). Further research is needed to identify the lower temperatures limits for eggs and larvae.

Information about larval sDPS green sturgeon in the wild is very limited. The USFWS conducts annual sampling for eggs and larvae in the mainstem Sacramento River. Larval green sturgeon appear in USFWS rotary screw traps at the RBDD from May through August (Poytress *et al.* 2010) and at lengths ranging from 24 to 31 mm fork length, indicating they are approximately two weeks old (CDFG 2002, USFWS 2002). USFWS data reveal some limited information about green sturgeon larvae, such as time and date of capture, and corresponding river conditions such as temperature and flow parameters.

Unfortunately, there is little information on diet, distribution, travel time through the river, and estuary rearing. Laboratory studies have provided some information about this initial life stage, but the relevance to fish in their natural habitat is unknown. Probably the most significant use of the USFWS data on larval green sturgeon has been to infer larval growth rates and correlations of these growth rates to temperature and flow conditions, making comparisons with larval green sturgeon growth rates in other river systems.

4. Juvenile Development and Outmigration

Young green sturgeon appear to rear for the first one to two months in the Sacramento River (CDFG 2002). Growth is rapid as juveniles move downstream and reach up to 300 mm the first year and over 600 mm in the first 2 to 3 years (Nakamoto *et al.* 1995). Juvenile sDPS green sturgeon have been salvaged at the Federal and State pumping facilities (which are located in the southern region of the Delta), and collected in sampling studies during all months of the year (CDFG 2002). The majority of juveniles that were captured in the Delta were between 200 and 500 mm indicating they were from 2 to 3 years of age based on age/growth studies from the Klamath River (Nakamoto *et al.* (1995). The lack of any juveniles smaller than approximately 200 mm in the Delta suggests that smaller individuals rear in the Sacramento River or its tributaries. Juvenile sDPS green sturgeon may hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard *et al.* (2005). Juvenile green sturgeon captured in the Delta by Radtke (1966) ranged in size from 200-580 mm, further supporting the hypothesis that juvenile green sturgeon enter the Delta after 10 months or at 200 mm in size. Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance between 15° C (59° F) and 19° C (66.2° F) (Mayfield and Cech 2004).

Radtke (1966) inspected the stomach contents of juvenile green sturgeon (range: 200-580 mm) in the Delta and found food items to include mysid shrimp (*Neomysis awatschensis)*, amphipods (*Corophium sp.)*, and other unidentified shrimp. In the northern estuaries of Willapa Bay, Grays Harbor, and the Columbia River, green sturgeon have been found to feed on a diet consisting primarily of benthic prey and fish common to the estuary. For example, burrowing thalassinid shrimp (mostly *Neotrypaea californiensis*) were important food items for green sturgeon taken in Willapa Bay, Washington (Dumbauld *et al.* 2008).

5. Estuarine Rearing

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

6. Ocean Rearing

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

In the summer months, multiple rivers and estuaries throughout the sDPS range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley *et al.* 2011). Genetic studies on green sturgeon stocks indicate that the green sturgeon in the San Francisco Bay ecosystem belong exclusively to the sDPS (Israel *et al.* 2009). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly *et al.* 2007, Heublein *et al.* 2009, Lindley *et al.* 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean, and why they aggregate episodically (Lindley *et al.* 2008, Lindley *et al.* 2011).

D. Green Sturgeon Viable Salmonid Population (VSP) Parameters

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a VSP. The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany *et al.* 2000a). The VSP concept measures population performance in term of four key parameters: abundance, population growth rate, spatial structure, and diversity. Although the VSP concept was developed for Pacific salmonids, the underlying parameters are general principles of conservation biology and can therefore be applied more broadly; here we adopt the VSP parameters for analyzing sDPS green sturgeon viability.

1. Abundance

In applying the VSP concept, abundance is examined at the population level, and therefore population size is perhaps a more appropriate term. Historically, abundance and population trends of sDPS green sturgeon has been inferred in two ways; first by analyzing salvage numbers at the State and Federal pumping facilities (see below), and second, by incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Both methods of estimating sDPS green sturgeon abundance are problematic as biases in the data are evident. Only recently has more rigorous scientific inquiry begun with Israel and May (2010) and Mora (unpublished data).

A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the CVP and SWP fish collection facilities. These data should be interpreted with some caution as operations and practices at the facilities have changed over the years, which may additionally affect the salvage data. Despite the potential pitfalls of using salvage data to estimate abundance for sDPS green sturgeon, recent trends show what appears to be a very steep decline in abundance, and potentially great cause for concern.

Beginning in 2010, more robust estimates of sDPS 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. Preliminary results of these surveys estimate an average annual spawning run of 272 fish (Mora unpublished data). This estimate does not include the number of spawning adults in the lower Feather River where green sturgeon spawning was recently confirmed.

2. Productivity

The parameters of green sturgeon population growth rate and carrying capacity in the Sacramento Basin are poorly understood. Larval count data from rotary screw traps set seasonally near the Red Bluff and Glen Colusa Irrigation District diversions. This data shows enormous variance between years with a high count of 3,700 larval captured in 2011 (Poytress *et al.* 2012). In other years, larval counts were an order of magnitude lower. There is some concern that the Sacramento River may have temperature regimes too cold for optimal larval growth, or for optimal hatching success in the upper regions of the river (Poytress *et al.* 2013). In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events (NMFS 2010b). It is unclear if the population is able to consistently replace itself or grow to greater abundance than levels currently observed. Other indicators of productivity, such as data for cohort replacement ratios, do not exist for sDPS green sturgeon. The long lifespan of the species and long age to maturity makes trend detection dependent upon data sets spanning decades, something that is currently lacking. Continuation of the acoustic telemetry work initiated on the Sacramento and Feather rivers (Mora *et al*. 2009, Seesholtz *et al*. 2014), as well as larval and juvenile studies carried out in the upper Sacramento River (Poytress *et al.* 2012) may eventually produce a more statistically robust analysis of productivity.

3. <u>Spatial Structure</u>

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During the late summer and early fall, subadults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett 1991, Moser and Lindley 2007).

Israel *et al.* (2009) found that green sturgeon within the Central Valley of California are sDPS green sturgeon. Acoustic tagging studies have shown that green sturgeon found within the San Francisco Bay estuary and further inland are exclusively sDPS green sturgeon.

In waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and the Delta and range up the Sacramento, Feather, and Yuba rivers. In the Yuba River, green sturgeon have been documented up to Daguerre Point Dam (Bergman *et al.* 2011). Migration past Daguerre Point Dam is not possible for green sturgeon, although potential spawning habitat upriver does exist. The same can be said about the Feather River where green sturgeon have been observed by DWR staff up to the Fish Barrier Dam. On the Sacramento River, Keswick Dam, located at RM (river mile) 302, marks the highest point on the river accessible to green sturgeon, and it might be presumed that green sturgeon would utilize habitat up to this point. However, USFWS sampled for larvae in 2012 at RM 267 and at RM 292 and no larvae were caught at these locations; habitat usage could not be confirmed any further upriver than the confluence with Ink's Creek (RM 264), which was a confirmed spawning site in 2011 (Poytress *et al.* 2012). Adams *et al.* (2007) summarizes information that suggests green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers. (Mora *et al.* 2009) analyzed and characterized known green sturgeon habitat and used that characterization to identify potential green sturgeon habitat within the Sacramento and San Joaquin River basins that now lies behind impassable dams. This study concludes that about 9 percent of historically available habitat is now blocked by impassible dams, but more importantly, this blocked habitat was of likely high quality for spawning.

Mora (unpublished data) revealed that green sturgeon spawning sites are concentrated in just a handful of locations. Mora found that in the Sacramento River just 3 sites accounted for over 50 percent of the green sturgeon documented in June of 2010, 2011, and 2012. This is a critical point with regards to the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure. Given a high concentration of individuals into just a few spawning sites, extinction risk due to stochastic events would be expected to be increased.

Green sturgeon were historically documented in the lower San Joaquin River; (Radtke 1966) reported catching green sturgeon at the Santa Clara Shoals (which is near the confluence to the San Joaquin River and the Sacramento River) and to a much lesser extent, west of Stockton. However, there is no known modern usage of the San Joaquin River by green sturgeon. Anglers have reported catching green sturgeon at various locations within the San Joaquin River basin; however none of these reports have been verified and no photographic evidence has surfaced. Unless stronger evidence can be shown, it is currently believed that green sturgeon do not use the San Joaquin River or its tributaries.

In summary, current scientific understanding indicates that sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and possibly even the Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent extirpation from the San Joaquin River narrows the habitat usage by the species, offering fewer alternatives to impacts upon any portion of that habitat.

4. <u>Diversity</u>

Diversity, as defined in McElhany *et al.* (2000a), includes genetic traits such as DNA sequence variation, and other traits that are influenced by both genetics and the environment, such as ocean behavior, age at maturity, and fecundity. Variation is important to the viability of a species for several reasons. First, it allows a species to utilize a wider array of environments than they could without it. Second, diversity protects a species from short term spatial and temporal changes in the environment by increasing the likelihood that at least some individuals will have traits that allow them to persist in spite of changing environmental conditions. Third, genetic diversity provides the raw material necessary for the species to have a chance to adapt to changing environmental conditions over the long term.

While it is recognized that diversity is crucial to the viability of a species in general, it is not well understood how well sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long term extinction risk. In general, a larger number of populations and number of individuals within those populations should offer increased diversity and greater chance of long term viability. The diversity of sDPS green sturgeon is probably low given current abundance estimates. Also, because human alteration of the environment is so pervasive in the California Central Valley, basic diversity principles such as run timing and behavior are likely adversely influenced through mechanisms such as diminished springtime flow rates as water is impounded behind dams, to give but one example.

5. Summary

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010a). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany *et al.* 2000a). The best available scientific information does not indicate that the extinction risk facing sDPS green sturgeon is negligible over a long term (~100 year) time horizon; therefore the sDPS is not believed to be viable. To support this statement, the PVA that was done for sDPS green sturgeon in relation to stranding events (Thomas *et al.* 2013) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, stated that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (National Marine Fisheries Service 2010a).

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their habitat needs.

2.3 Environmental Baseline

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

A. Status of the Species and Critical Habitat in the Action Area

1. Status of the Species within the Action Area

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

a. *Sacramento River Winter-Run Chinook Salmon*

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 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. 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.

b. *Central Valley Spring-Run Chinook Salmon*

A similar application of the CVP and SWP salvage records of Central Valley spring-run Chinook salmon indicates that juveniles first begin to appear in the action area in January, but that a significant presence does not occur until March and peaks in April (17.2 and 65.9 percent of average annual salvage, respectively). By May, the salvage of Central Valley spring-run Chinook salmon juveniles declines sharply and essentially ends by the end of June (15.5 and 1.2 percent of average annual salvage, respectively). This pattern is further supported and consistent with salmonid passage estimates derived from rotary screw trap data collected by USFWS dating back to 2003, which indicate two significant peaks in the annual passage of juvenile spring-run Chinook salmon at RBDD occurring in the months of December and April. Currently, all known populations of Central Valley spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been extirpated, with the last known runs on the San Joaquin River being extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Kern-Friant irrigation canal.

c. *California Central Valley Steelhead*

CCV steelhead occur in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Small, remnant populations of CCV steelhead are 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 USFWS and CDFW on the mainstem of the San Joaquin River upstream from the City of Stockton routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin Basin during the months of April and May.

d. *Southern DPS of North American Green Sturgeon*

The numbers of sDPS green sturgeon collected at the SWP and CVP salvage facilities throughout the year 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, yet appear to be most prevalent during the months of 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. It is believed that juvenile fish utilize the Delta for rearing for a period of approximately 3 years. The proximity of the CVP and SWP facilities to the action area would indicate that sub-adult and juvenile green sturgeon have a strong potential to be present within the action area during the proposed project, but that their population density would be low in these waters.

2. Status of Critical Habitat Within the Action Area

The action area occurs within two separate hydrologic units (HU) corresponding with the two separate deep water ship channels: one on the Sacramento River within the Lower Sacramento HU (18020109), and the other on the San Joaquin River within the San Joaquin Delta HU (18040003). The action area includes areas designated as critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

The PBFs of designated critical habitat for Central Valley spring-run Chinook salmon and CCV steelhead 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 Sacramento River winter-run Chinook salmon 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 as well as adult and juvenile freshwater migration corridors by all three of the listed salmonid species. No spawning habitat for any of the listed salmonids or sturgeon occurs within the action area.

In regards to the designated critical habitat for the sDPS of green sturgeon, the action area includes PBFs concerned with: 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 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 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 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 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 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 and the untreated discharge of numerous agricultural waterways are emptied into the channels flowing into the 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*.).

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for all of the species considered. Both the adult and juvenile life stages of each listed species considered in this opinion must pass through some segment of the action area as they transit between the ocean and upstream spawning and freshwater rearing areas on the tributary watersheds, and during their passage through the region again during the downstream migrations of juveniles from all of the species considered as well as the returning adult sturgeon and steelhead runbacks. Therefore, it is of critical importance to the long-term viability of all four of the listed ESUs and DPSs to maintain a functional migratory corridor and freshwater rearing habitat throughout the action area.

B. Factors Affecting the Species and Habitat in the Action Area

The action area encompasses a small portion of the area utilized by Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon. Many of the range-wide factors affecting these species are discussed in the *Status of the Species and Critical Habitat* section 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 project.

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 basins' tributaries. Consequently, managed flows in the main stem of the rivers 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 is severely reduced by the combined storage capacity of the different reservoirs located throughout the basins' watersheds. Very little of the natural hydrologic input 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 Sacramento and San Joaquin rivers and the lower portions of the tributaries feeding into them. High summer water temperatures in the lower portions of the two rivers frequently exceed 72^{o}F, and create a thermal barrier to the migration of adult and juvenile salmonids (CDEC database).

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 (SRA) 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 (USFWS 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 (*i.e.*, 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 (USFWS 2000). Recruitment of LWD is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining near shore refuge areas.

Point sources and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Critical Habitat* section. 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 (USFWS 1995b). Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, water quality, NIS, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

2.4 Effects of the Action

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

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. § 1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536). This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the establishment of a final rule (81 FR 7414; February 11, 2016) that amends the regulations governing section 7 consultations under the ESA to revise the definition of "destruction or adverse modification" of critical habitat in order to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This opinion assesses the effects of the proposed project on the designated critical habitats for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of Critical Habitat* and *Environmental Baseline* sections of this opinion, NMFS provided an overview of the critical habitats that were likely to be adversely affected by the proposed project.

NMFS generally approaches the critical habitat modification analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed project on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; and others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

1. <u>Information Available for the Assessment</u>

To conduct this assessment, NMFS examined information from a variety of sources including: detailed background information on the status of species and critical habitat that has been published in a number of documents including peer reviewed scientific journals, primary reference materials, government and non-government reports, the *Sacramento and Stockton Deep Water Ship Channel Maintenance Dredging and Bank Protection Project, California 10-Year Programmatic Biological Assessment*, the *Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging and Dredge Material Placement Projects 2014 Fish Community, Entrainment and Water Quality Monitoring Report* dated May 2015, and supplemental supporting information and materials provided by the Corps to NMFS through email correspondence as they became available over the course of the consultation. Additional information investigating the effects of the proposed project on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was obtained from the aforementioned resources. Final detailed plans for the specific dredging and bank stabilization activities proposed and fisheries monitoring plans have not been completed; therefore, NMFS has analyzed the effects of the project without relying on monitoring efforts to avoid or minimize effects on listed species.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

Additional information from fish monitoring studies conducted by the USFWS and CDFW regarding salmonid density in the Sacramento and San Joaquin rivers was incorporated into the calculations for risk assessment. Turbidity effects utilized information pertaining to salmonids in general, rather than to the specific listed species present in the action area due to a lack of direct information concerning this response.

The degree to which contaminants would be suspended during dredging and effluent return from dredge material placement sites, and the effects of the contaminants on listed salmonids and sturgeon are not clear. The Corps routinely tests sediments for contaminants across all areas where dredging is proposed to occur prior to the commencement of dredging activities in accordance with the regulatory requirements for obtaining Section 401 Water Quality Certification under the Clean Water Act, as administered by the Central Valley Regional Water Quality Control Board's (CVRWQCB) waste discharge requirements. The Corps has not found contaminants in concentrations that exceed those existing regulatory criteria, however, specific regulatory criteria have not yet been designated for all contaminants or life history events relevant to the listed species under consideration in this opinion.

Another area of uncertainty in this consultation is how dredging or disposal effluent discharges actually distribute contaminants. If the dredging equipment contains the sediments effectively after excavation, the distribution of contaminants would be greatly minimized. Conversely, if contaminated sediments are not contained effectively, they could be widely distributed. This is the primary concern with disposal operations. Effluent return from disposal sites potentially would re-suspend any contaminants present. The Corps, however, has tested sediments within the action area and determined that they would not exceed the existing regulatory criteria, as previously described, for a range of contaminants.

In assessing the impacts of anthropogenic noise on the listed anadromous fish species, NMFS used the available data for several different species of fish for which acoustic experimental data is available, including the hearing specialist fathead minnow (*Pimephales promelas*) and the hearing generalist, pink snapper (*Pagrus auratus*). Protective acoustic levels were then determined that were appropriate for fish in general, due to a lack of data specific to salmonids.

In a recent review of available information on the effects of anthropogenic sound generated by construction activities on the west coast of North America, Hastings and Popper (2005) specifically cited the lack of salmonid data as a critical gap in the scientific record for evaluating noise impacts, and recommended increased and focused studies on this group of fish.

The fate of salmonids and sturgeon that migrate unto the upper section of the Sacramento DWSC is not completely understood. Prior to ceasing lock gate operations, fish could pass through to the Sacramento River when the gates were opened for navigation purposes. In at least one instance several hundred adult fish moved upstream through the lock when the gates were opened (Corps 1995). Salmonids blocked behind the locked gates are potentially vulnerable to harvest by anglers or to die without spawning.

The status of green sturgeon in the upper section of the Sacramento DWSC is unknown; however, more abundant white sturgeon (*Acipenser transmontanus*) have been captured in the Yolo Bypass toe drain, which is accessed from Cache Slough and is adjacent to the upper section of the Sacramento DWSC (Harrell and Sommer 2003).

B. Assessment

The Corps maintenance dredging is proposed for 10 dredging seasons (*i.e.*, from August 1 through October 31 for the Sacramento DWSC and from August 1 through November 30 for the Stockton DWSC) from 2016 through 2025. Dredging at a particular location is expected to occur intermittently, with an average dredging cycle of 3 to 4 years between actions for some highly accreting areas, while other sections may be dredged less than once per decade. Bank stabilization activities will occur on sections deemed in need of repair, restoring them to their original configuration, between June 15 and November 30 each year for the 10-year duration of this opinion. Project impacts on the listed anadromous fish species are expected to include both direct impacts to fish present in the action area during the activities, and indirect impacts that may occur later in time or downstream, and negatively affect fish occurring through the action area at any time of the year. Direct negative effects are expected to result from re-suspension of sediment and toxic chemicals, entrainment (including that of benthic food organisms), anthropogenic noise from the operation of dredging equipment, effluent returns from DMPS, and bank stabilization work. Exposure of listed salmonids to direct effects of the project is expected to be avoided or minimized largely because in-channel work in the mainstem Sacramento and San Joaquin rivers (*i.e.*, in the lower sections of the Sacramento and Stockton DWSCs, respectively) will occur primarily during the summer and fall, when salmonid abundance is expected to be low. Few salmonids or green sturgeon are anticipated to occur at all in the upper, manmade sections of both the Sacramento and Stockton DWSCs. Long term, indirect effects are expected to result from impacts to habitat such as bathymetry changes or the removal of vegetation. A brief discussion of the likelihood of exposure of listed fish by month, species, and life stage follows:

For Sacramento River winter-run Chinook salmon, the proposed work window for project activities in the mainstem Sacramento River and associated sloughs (June 15 through November 30) should preclude most instances of exposure to all but the earliest migrating adults and juveniles. Early adults are likely to be present in the action area in December; early juveniles may be present in November and December, especially if significant rainfall events occur to trigger their outmigration behavior. The duration of exposure for straying adults in the manmade section of the DWSC to the effects of the proposed project likely would be on the order of days.

No adult Central Valley spring-run Chinook salmon are expected to occur in the action area during the period from June 15 through November 30. Yearling fish may appear in the Sacramento River as early as late October, but are not likely to occur in any substantial numbers until after February when the bulk of juvenile spring-run Chinook salmon begin to enter the Delta.

During the period from September through the end of November, adult CCV steelhead may be in the proximity of the dredging and bank stabilization activities as proposed; however, NMFS expects them most likely to be present during the months of December through February, which is the peak of their spawning migration. Adult steelhead begin to migrate into the region's watersheds during this period, particularly when increased attractant flows are being released by upstream reservoirs to enhance fall-run Chinook salmon spawning runs in the San Joaquin River tributaries or early winter rains create increased flows in the system. Prior to the fall attractant flows, low dissolved oxygen conditions may occur and cause adult steelhead to linger downstream of the Port of Stockton while they wait for more favorable water quality conditions.

The peak of juvenile CCV steelhead emigration from their tributaries in the Sacramento and San Joaquin valleys occurs during the period between February and May. Therefore, conducting project activities from June 15 through November 30 should avoid impacts to the majority of outmigrating juvenile steelhead smolts. There are, however, larger steelhead smolts that migrate at other times of the year, including the fall and early winter period, and may therefore be exposed to the dredging activities during their passage through the action area. As with adults, NMFS expects the most likely period for them to be present is in the month of December.

All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and CCV steelhead from the Sacramento and San Joaquin river drainages have the potential to be exposed to the long-term effects of the Corps' maintenance dredging actions. The total number exposed to negative effects associated with the altered habitat could range from several hundred to a few thousand individuals, depending on the timing of dredging activities and the run size for that year.

The sDPS green sturgeon are anticipated to be present in small numbers throughout the action area during the proposed project. Although information for the density of sDPS green sturgeon presence currently is not available, their continual but infrequent occurrence in sampling studies targeting other fish species indicates that they may be present throughout the year within the Delta and thus vulnerable to both short-term and long-term negative effects of the project.

1. Turbidity

Dredging and the disposal of dredged materials would disturb and suspend a significant volume of benthic sediment. Previous estimates of dredge-created turbidity have indicated that dredging will result in an increase in total suspended solids downstream of the dredging action, which should not greatly change conditions in the DWSC compared to background turbidity levels.

Quantifying turbidity levels, and their effect on fish species, is complicated by several factors. First, turbidity from an instream activity will typically decrease as distance from the activity increases. How quickly turbidity levels attenuate depends on the quantity of materials in suspension (*e.g*., mass or volume), the particle size of suspended sediments, the amount and velocity of ambient water (dilution factor), and the physical/chemical properties of the sediments. Second, the impact of turbidity on fishes is not only related to the turbidity levels, but also the particle size of the suspended sediments.

For salmonids, the moderate levels of turbidity expected to be generated by the proposed project may elicit a number of behavioral and physiological responses (*i.e*., gill flaring, coughing, habitat avoidance, increase in blood sugar levels) which indicate some level of stress (Bisson and Bilby 1982, Sigler *et al*. 1984, Berg and Northcote 1985, Servizi and Martens 1992). The magnitude of these stress responses is generally higher when turbidity is increased and particle size decreased (Bisson and Bilby 1982, Servizi and Martens 1987, Gregory and Northcote 1993). Although turbidity may cause stress, Gregory and Northcote (1993) have shown that moderate levels of turbidity [35-150 Nephelometric Turbidity Units (NTU)] accelerate foraging rates among juvenile Chinook salmon, likely because of reduced vulnerability to predators (camouflaging effect).

When the particles causing turbidity settle from the water column, they contribute to sedimentation. Turbidity and subsequent sedimentation can influence the exchange of streamflow and shallow alluvial groundwater, depress riverine productivity, and contribute to decreased salmonid growth rates (Waters 1995, Newcombe and Jensen 1996).

The Corps proposes the use of suction dredging, which involves excavating sediments with a cutterhead suction dredge. Suction dredging has the potential to create turbidity primarily where the excavation is occurring as the interface between the excavating apparatus and sediments is not contained. It is expected that turbidity resulting from dredging and dredged material disposal would be intense in the vicinity of the activity themselves, but would rapidly attenuate with time and space. The conservation measures proposed to minimize the impacts of hydraulic dredging (*e.g*., reducing the cutterhead rotation speed and reducing swing speed) are specifically intended to reduce the volume of and broadcast area of suspended sediment and should preclude large changes to the conditions in either of the DWSCs compared to background turbidity levels.

The Corps proposes to implement a number of additional techniques to minimize turbidity effects resulting from project operations. First, the Corps would monitor turbidity levels and modify dredging operations to avoid prolonged negative effects. Second, the Corps would dispose of dredge material in a manner to limit the exposure of listed fish by placing the material in upland disposal sites and by meeting water quality standards for effluent discharge from these sites. The Corps would also use best management practices at disposal locations to prevent remobilization of sediments, and subsequent turbidity, through dewatering activities or storage.

Based on the timing of the dredging actions in the action area (August 1 through October 31 in the Sacramento DWSC and August 1 through November 30 in the Stockton DWSC), NMFS expects the majority of the impacts created by dredging activity to be experienced by adult CCV steelhead migrating upstream to the watersheds of the Sacramento and San Joaquin rivers and early migrating Sacramento winter-run Chinook salmon juveniles entering the Delta from the Sacramento River system during the later portion of the dredging season. Although some steelhead smolts may be migrating downstream at this time, their numbers are expected to be low compared to the peak of migration in spring and would tend to be associated with rain events or pulse flow operations on the tributaries. Increased flows in the main channel of the Sacramento and San Joaquin rivers resulting from pulse flows or winter precipitation would be expected to ameliorate the negative effects of the dredging action by shortening the duration of migration through the action area and diluting the re-suspended sediments in the water column. Similarly, winter-run Chinook salmon juveniles often exhibit early migrational behavior that is correlated with rainfall events and increased turbidity in the Sacramento River. The exposure risk to sDPS green sturgeon is less clear. Juvenile and adolescent green sturgeon could be found year-round in the Delta, particularly in the deeper sections of the action area based on sturgeon behavior and their preference for deep holes in river channels.

2. Contaminants

Disturbing benthic sediments through dredging and dredge material disposal, and effluent return from DMPS, is expected to mobilize and distribute a variety of contaminants. The Corps has identified polycyclic aromatic hydrocarbons (PAHs), organophosphates, chlorinated herbicides, ammonia, oil, grease, glyphosate, a-amino-3-hydroxy-5-methyl-4-isoxazolepro-pionate (*i.e.*, AMPA), dioxin, heavy metals, and other, as potential contaminants. Some of these contaminants may be acutely or chronically harmful to salmonids (Allen and Hardy 1980). The Corps has tested sediments for contaminants across all areas where dredging is proposed, and has not found contaminants in concentrations that exceed any of the existing regulatory criteria imposed by the requirements for Section 401 Water Quality Certification under the Clean Water Act. However, many contaminants lack defined regulatory exposure criteria that are relevant to listed salmonids, and may have effects on salmonids (Ewing 1999).

If contaminants are released during dredging or disposal activities, their effects may be subtle and difficult to directly observe. The effects of bioaccumulation are of particular concern as pollutants can reach concentrations in higher trophic level organisms (*e.g*., salmonids) that far exceed ambient environmental levels (Allen and Hardy 1980). Bioaccumulation may therefore cause delayed stress, injury, or death as contaminants are transported from lower trophic levels (*e.g.*, benthic invertebrates or other prey species) to predators long after the contaminants have entered the environment or food chain. It follows that some organisms may be negatively affected by contaminants while regulatory thresholds for the contaminants are not exceeded during measurements of water or sediments.

Sublethal or nonlethal effects indicate that death is not the primary toxic endpoint. Rand (1995) stated that the most common sublethal endpoints in aquatic organisms are behavioral (*e.g.*, swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (*e.g.*, growth, reproduction, and development), biochemical (*e.g.*, blood enzyme and ion levels), and histological changes. Some sublethal effects may result in indirect mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish of the same species may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Exposure to sublethal levels of contaminants might have serious implications for salmonid health and survival. Studies have shown that low concentrations of commonly available pesticides can induce significant sublethal effects on salmonids. Scholz *et al*. (2000) and Moore and Waring (1996) have found that diazinon interferes with a range of physiological biochemical pathways that regulate olfaction, negatively affecting homing, reproductive, and anti-predator behavior of salmonids. Waring and Moore (1997) also found that the carbofuran had significant effects on olfactory mediated behavior and physiology in Atlantic salmon (*Salmo salar*). Ewing (1999) reviewed scientific literature on the effects of pesticides on salmonids and identified a wide range of sublethal effects such as impaired swimming performance, increased predation of juveniles, altered temperature selection behavior, reduced schooling behavior, impaired migratory abilities, and impaired seawater adaptation.

Other non-pesticide compounds that are common constituents of urban pollution and agricultural runoff also negatively affect salmonids. Exposure to chlorinated hydrocarbons and aromatic hydrocarbons causes immunosuppression and increased disease susceptibility (Arkoosh *et al*. 1994). In areas where chemical contaminant levels are elevated, disease may reduce the health and survival of affected fish populations (Arkoosh *et al*. 1994).

As noted above, the literature suggests that certain contaminants may affect the biology of salmonids. At present, regulatory thresholds are likely inadequate to account for these effects (*i.e.*, some contaminants do not have salmonid exposure criteria or bioaccumulation criteria). Therefore, we expect the proposed project to have sublethal effects on listed salmonids as described above. We also anticipate green sturgeon to experience sublethal effects to the same or a greater extent than listed salmonids due to their year-round presence in the action area, and dermal contact with sediment because of their benthic lifestyle.

Until exposure criteria can be refined and expanded, the Corps has committed to implementing conservation measures that are intended to minimize the exposure of listed anadromous fish species to contaminants to the greatest extent possible, for example, by dredging during the in-water work windows, continuing to sample sediments for contaminants, refraining from in-water disposal of contaminated sediments, and implementing best management practices to prevent fuel spills, hydraulic leaks, *etc*., during all dredging and disposal operations.

3. Entrainment and Harassment

NMFS believes the probability of entraining winter-run, Central Valley spring-run Chinook salmon or steelhead in the hydraulic dredge is very low because these fish are likely to avoid the immediate vicinity of dredging operations, and because dredging operations proceed slowly. Additionally, the Corps has committed to a number of conservation measures to reduce the probability of entrainment occurring during future dredge operations. Direct effects to listed steelhead and Chinook salmon species by entrainment are minimized by not operating the dredge when the cutterhead is off the river bottom. The cutterhead would remain on the bottom of the water column to the greatest extent possible and only be raised 3 feet off the bottom when necessary during maintenance dredging operations. The cutterhead suction pumps would only be turned on when necessary with the cutterhead not more than 3 feet off the channel bottom. This measure is primarily to protect juveniles from entrainment because adults have sufficient swimming capacity to avoid entrainment unless they swim directly into the cutterhead.

Furthermore, most dredging will take place in water deeper than 20 feet. Steelhead or Chinook salmon smolts are not expected at this depth during their seaward migration, thus further insulating them from the effects of the flow fields surrounding the cutterhead. Adult salmonids that may encounter the hydraulic dredge would likewise be able to avoid and escape entrainment due to their greater swimming speed. Overall, no adults and few juvenile listed salmonids are expected to be entrained in the dredge, although any fish entrained in the dredge would be expected to die due to physical injury or suffocation in sediment coupled with the unlikelihood of release back into the river channel once entrained.

Juvenile and adolescent green sturgeon may be at an elevated risk of entrainment from the hydraulic dredge. Based on data for salmon entrainment (Reine and Clark 1998), sturgeon juveniles were entrained by hydraulic dredging at high rates on the Columbia River from localized areas known to have aggregations of sturgeon (sturgeon holes). The behavior of sturgeon apparently places them at risk of entrainment from dredging actions due to their preference for deep channels and holes (*i.e.*, the DWSCs) and their reluctance to move away from those areas even when disturbed. Since NMFS assumes that sDPS green sturgeon will occupy the Delta year-round during their juvenile and sub-adult phases, exposure to entrainment may occur throughout the entire dredging window for the Sacramento and Stockton DWSCs.

4. Rearing Habitat

The Corps proposes to annually dredge approximately 500,000 acre feet of silt and sand accumulations in portions of the lower Sacramento and San Joaquin rivers and artificial channels of the DWSCs. The number, location, and size of these sites will vary from year to year and will represent varying degrees of suitability as juvenile rearing habitat for the listed anadromous fish species. Suitability is determined in part by depth, substrate type, and distance from the shoreline.

The most important habitat attribute of the riverbed to listed anadromous fish species in the action area is the production of food items for rearing and migrating juveniles. Oligochaetes and chironomids (dipterans) are the dominant juvenile Chinook salmon, steelhead, and sDPS green sturgeon food items produced in the silty and sandy substrates in this area.

Populations of these organisms would be entrained by the hydraulic suction dredge, particularly small demersal fish and benthic invertebrates. Reine and Clark (1998) estimated that the mean entrainment rate of a typical benthic invertebrate, represented by the grass shrimp, when the cutterhead was positioned at or near the bottom was 0.69 shrimp/cubic yard but rose sharply to 3.4 shrimp/cubic yard when the cutterhead was raised above the substrate to clean the pipeline and cutterhead assembly. Likewise, benthic infauna, such as clams, would be entrained by the suction dredge in rates equivalent to their density on the channel bottom, as they have no ability to escape. The loss of benthic food resources, such as amphipods or isopods, could reduce fish growth rates and increase the energy expended searching for food, depending on the density of the animal assemblages on the channel bottom. This would be more likely to occur to sturgeon, which are specialized benthic feeders, but also may affect juvenile salmon and steelhead. NMFS believes that small invertebrates such as annelids, crustaceans (amphipods, isopods), and other benthic fauna would be unable to escape the suction of the hydraulic dredge and be lost to the system. Also, many benthic invertebrates have pelagic, surface-oriented larvae; therefore the loss of these benthic invertebrates may reduce the abundance of localized zooplankton populations in the upper regions of the water column where juvenile salmonids migrate through the Delta. The timing of the dredging cycle (from August 1 through November 30 each year) may preclude forage base replacement by recruitment from surrounding areas prior to the following winter and spring migration period of juvenile steelhead through the action area (Nightingale and Simenstad 2001). However, as these organisms occupy habitat types that are prone to disturbance under natural conditions, they would likely rapidly recolonize dredged areas by drifting and crawling from adjacent non-disturbed areas (Mackay 1992).

The time needed to recolonize the dredged area is unknown and is complicated by the variable maintenance dredging cycles and reach locations. These variable dredging cycles may preclude a “natural climax” benthic invertebrate assemblage from re-establishing itself in a given specific reach of either of the DWSCs. However, outmigrating salmonids and rearing green sturgeon should be able to find alternative foods and foraging areas outside of the channel and in adjoining channels feeding into the DWSC. Overall, the maintenance dredging is not likely to change the benthic habitat to the extent that listed species would be adversely affected in the reaches to be dredged, particularly in the upper manmade section of the DWSC.

5. <u>Bank Stabilization</u>

Construction activities associated with stream bank protection may facilitate the transport of sediment into the stream channel and increase turbidity resulting from precipitation events. The effects of suspended sediment and turbidity on fish are discussed above.

The use of rock riprap to stabilize streams can substantially alter both site conditions and adjacent riverbed and riverbank habitat, thereby significantly reducing suitability of the habitat for salmonids. Although rock riprap can provide some habitat features used by salmonids, such as inter-rock space, there is evidence that fish densities at rock riprap banks are reduced (Schmetterling 2001). The use of rock riprap to stop bank erosion by its nature tends to change riverbed and riverbank characteristics, and can effectively change the physical processes that maintain a dynamic equilibrium of stream system form and function. The following generalized discussion of the effects of bank stabilization on fish habitat applies to the proposed project.

A comparative review of effects of riprap (Schmetterling 2001) has indicated that fish densities at stream locations with riprap banks are reduced as compared to areas with natural banks. This is true even when compared to actively eroding cut banks (Schaffter *et al*. 1983, Michny and Deibel 1986). The use of riprap either results in site characteristics that limit suitability for fish at various life stages (Li *et al*. 1984, Beamer and Henderson 1998, Peters *et al*. 1998, North *et al*. 2002), or perpetuates detrimental conditions that may restrict or limit fish production, such as channelizing the stream (Knudson and Dilley 1987). Even when rock may contribute to habitat diversity within the alluvial stream system, in the immediate area, habitat complexity is simplified and beneficial biological responses tend to be of limited duration and have greater variability (Beamer and Henderson 1998, Peters *et al*. 1998, Schmetterling 2001). The effect of rock riprap varies with fish species and age class. Chinook salmon are often displaced from riprap sites, although there has been some limited occurrence of Chinook salmon associated with rock barbs during spring flows (Li *et al*. 1984, Beamer and Henderson 1998, Peters *et al*. 1998, North *et al*. 2002). Rainbow trout (and by inference, steelhead) were less affected than Chinook salmon, showing a limited preference for rip-rap and rock barbs (Li *et al*. 1984, Beamer and Henderson 1998, Peters *et al*. 1998). Decreases in juvenile fish densities were more evident than in adults, including juvenile rainbow trout (Li *et al*. 1984, Beamer and Henderson 1998). Rock riprap can also result in increased densities of predatory fish (Knudson *et al*. 1987, North *et al*. 2002).

The use of rock riprap effectively changes the localized hydraulics, substrate, and available food and cover for fish at stream sites where it is used. There is an indication that the flow regimes created by rock riprap significantly disrupt juvenile fish. Juvenile fish are associated with lower velocity flows at the riverbed interface, holding for food, finding potential hiding places in the gravels, and/or avoiding larger predatory fish in deeper waters. Rock riprap can disrupt flows, reduce food delivery, and create difficult swimming for smaller fish (Schaffter *et al*. 1983, Michny and Deibel 1986). During higher spring flows, juvenile Chinook salmon were found behind spur dikes (Li *et al*. 1984).

These features can provide a simplified flow modulator for a limited period of time. Complex large wood associated with stream banks, even at riprap banks, demonstrates more flow modulation over greater time frames at different water elevations, as well as providing the small intricate space for juveniles to escape predation (Peters *et al*. 1998, Beamer *et al*. 1998). In general, juveniles tend to hug the banks during winter and spring (seeking refuge from higher flows, food, and cover) and tend to move to the main channel during summer. Adults tend to be more oriented to the deep channel, and utilize eddy lines and flow deflectors (Li *et al*. 1984, Carlson *et al*. 2000). Where more natural stream bank features occur, and shallow water gravel benches or large complex wood deposits have been either maintained or incorporated into riprap, fish densities increase (Schaffter *et al*. 1983, Michny and Deibel 1986, Beamer and Henderson 1998, Peters *et al*. 1998).

Riprap not only modifies the riverbed and riverbank habitat, but as its primary purpose, it stops natural stream processes that maintain a functioning stream system. By "fixing" the stream, rock riprap limits habitat formation and transitions that result from dynamic stream processes. This reduces the likelihood that negative effects from riprap would be mitigated over time. Stream migration, channel changes, flooding, ground water interchange, gravel supply, and large wood supply are significant elements of natural stream processes that can be impacted by riprap. It is generally understood that vegetated stream edges, floodplains, and riparian areas contribute to supporting fish and the stream system as a whole (Opperman 2012). This is true of the subsurface hyporheic zone (Bolton and Shellberg 2001). Stream erosion and adjustments are natural processes to which fish have adapted. A typical disturbance such as channel degradation or significant alteration is followed by formation of various stream system features over time that existed before the alteration, including floodplain and stable vegetated hillslopes and riparian areas (Bolton and Shellberg 2001). Stabilizing banks with rock riprap fixes the stream in place, and limits any adjustment processes and/or formation of natural stream features.

Adult fish migration is affected by stream obstructions, water quality, and stream flow. Active stream channel migration typically will maintain a deep water channel feature and provide for the upstream movement of adult salmon. Bank stabilization activities associated with the proposed project would tend to fix the location of the channel, resulting in localized changes to the channel form, deepening some areas and shallowing other areas. The project area has been extensively leveed. The restriction of riprap activities to the manmade section of the DWSC will not result in a substantial change in stream channel processes. Furthermore, the proposed project is not expected to directly or indirectly block the stream channel or affect flows to the extent that they would impair the migration of salmonids or sDPS green sturgeon.

Juvenile salmon rear within the project area and emigrate past the project area during winter and early spring. Juvenile salmonids require food, cover, and refuge from high velocity flows. Although the fine sediments associated with the project's location do not typically produce substantial numbers of invertebrates used by salmon, terrestrial and aquatic invertebrates can accumulate at this location from riparian or upstream sources. Shallow water areas and small structural elements that create localized eddy currents can provide space for juveniles to hide and avoid predation. During high water events, flooding of stream terraces can introduce new food sources and provide the shallow-water, low-velocity space for juvenile refuge. The proposed project will limit formation of channel features and habitat used by juveniles for feeding, hiding, and refuge. The placement of rock riprap can increase channel scour, limit active channel forming processes, and simplify available habitat during high water. Rock riprap does add structure with openings between rocks. Larger rocks provide bigger spaces that may be used by salmon for feeding and hiding, as well as by predators that prey upon salmonids. The current natural channel has been affected by local land uses that have restricted stream migration. The proposed project is the maintenance of existing riprap in the artificial ship channel only and therefore will not significantly add to, or further restrict, stream processes and diversity and the development of complex stream channel habitat.

Currently the riverbank has been simplified through the construction of levees and the removal of riparian vegetation. Hardening the bank will limit potential for establishing vegetative structure and diverse pool habitat at the edge of the bank. However, the proposed project would add some structure and roughness to the stream along the edge and create space for both juvenile salmon feeding and hiding and the predatory fish that prey upon them. Green sturgeon, which prefer deeper habitat, would be less affected by bank stabilization activities.

2.5 Cumulative Effects

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

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in the action area may negatively affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the rivers and streams that flow into the Delta. Unscreened agricultural diversions along the Sacramento and San Joaquin rivers and throughout the Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids and sturgeon 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 and sturgeon reproductive success and survival rates (Dubrovsky *et al*. 1998, 2000; Daughton 2003).

Increased urbanization and housing developments can impact habitat by altering watershed characteristics and changing both water use and stormwater runoff patterns. Increased urbanization is also expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity. 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 will result in reduced habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and sturgeon. Increased recreational boat operation in the Delta is also anticipated to result in elevated contamination from the operation of engines on powered watercraft entering the water bodies of the Delta.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

In general, the direct negative effects to Chinook salmon and steelhead in either of the DWSCs will be substantially attenuated by the work window proposed by the Corps, which will greatly reduce the exposure of listed salmonids. Dredging activities are to be restricted to the period from August 1 to October 31 in the Sacramento DWSC, and from August 1 to November 30 in the Stockton DWSC, although effluent from the DMPS may continue to enter the channels for a period of time after the work window ends. Bank protection activities will take place from June 15 to November 30 during each year of the 10-year period of the proposed project. The proposed work window will avoid the majority of steelhead migration through the Delta from the Sacramento and San Joaquin river basins. In the action area, adult and juvenile steelhead are expected to be exposed primarily during late November and December, when cool and rainy weather is likely to promote migration. Likewise, early downstream juvenile emigrants of the winter-run and spring-run Chinook salmon runs from the Sacramento River basin should not enter the action area until at least late October and more likely late November to early December when dredging in the main channel of the Sacramento and San Joaquin rivers is nearing completion. Few adult winter-run Chinook salmon and no adult spring-run Chinook salmon are expected to be exposed to the direct negative effects of the proposed project Green sturgeon presence within the action area is considered to be year-round, with juveniles entering the Delta during the late summer and fall and potentially rearing there for several months to years before migrating to the ocean. However, because winter-run, Central Valley spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to occur primarily in the lower section of the Sacramento DWSC, which forms part of the major migration corridor through the Delta, fish from these ESUs/DPSs are expected to be exposed to the effects of the proposed project mostly in the downstream reaches of the proposed areas to be dredged in both the Sacramento and Stockton DWSCs. Very few listed fish should be exposed to the negative effects of bank protection activities in particular, because these activities will occur primarily in the upper reaches of the Sacramento and Stockton DWSCs. The proposed project is expected to contribute to the continuation of poor quality habitat conditions in the action area, and both DWSCs in particular, that may be experienced by fish present throughout the year.

A. Effects on Listed Species

The short-term effects of the proposed project are expected to result in an increase in the near field suspended sediment ambient loads, which should not greatly change conditions in the action area compared to background turbidity levels. Furthermore, the increased turbidity zone should be concentrated near the bottom of the channel within close proximity of the cutterhead before being diluted by water flow in the channel. Therefore, few listed salmonids in the action area are expected to be directly affected by the turbidity levels generated by the proposed project, as salmonids should occupy the shallower, near surface water levels during emigration. Overall, the changes in turbidity and suspended sediment associated with the proposed project, therefore, are expected to negatively affect listed species primarily by low-level, long-term alteration of habitat conditions, which may affect feeding or predation rates. The potential for the increase in suspended sediment to negatively affect green sturgeon is unclear. Although sturgeon are demersal fish closely associated with the bottom substrate, and therefore could be exposed to the elevated zones of turbidity along the bottom, they also are well-suited for these conditions. In particular, they feed by taste and feel with their barbels, even shoveling up sediment with their snouts when searching for food (Moyle 2002). Negative effects are more likely to occur from entrainment of small individuals in the dredge.

The contaminants associated with the dredge material and the exposure of the new horizon may negatively affect exposed aquatic organisms. The levels of contaminants present in the sediment may not exceed the acute toxicity concentrations or the different water quality guidelines even if the sediment quality criteria are exceeded. Nevertheless, their elevated concentrations do present an increased risk to the health of exposed salmonids, even though the exposure may not result in immediate mortality.

Decant waters from DMPS are not expected to be experienced by all migrating salmonids to the same degree due to the temporal and spatial variances of the swim path of the fish and the location of the discharge plume. Fish that migrate near the riverbank will be more likely to encounter the discharge plume during their upstream movements than fish in the middle of the channel. Likewise, fish that move during periods of discharge will have the potential to encounter the discharge plume compared to fish that move through the river system when there is no discharge.

The hydraulic suction head of the dredge creates a zone of inflow around the cutterhead of the dredge. Animals that are too close to the cutterhead have the potential to be entrained into the suction pipeline of the dredge and carried to the DMPS on shore. As described previously, the Corps has indicated that dredging will take place between August 1 and October 31 in the Sacramento DWSC and between August 1 and November 30 in the Stockton DWSC, inclusively, in order to avoid the majority of listed salmonids in the action area. The dredge will be operated at least 20 feet below the water surface, with the hydraulic suction and cutterhead operating only in the bottom substrate. The cutterhead may be raised briefly to clear obstructions, but never more than 3 feet above the substrate. Fish entrainment by the hydraulic dredging in this scenario is very unlikely due to the timing of dredging, the depth, and the flow fields around this particular dredging operation. In order for entrainment of salmonids to occur, the fish would have to be concentrated around the dredge head or the dredge operated at water depths where the salmonids would normally be aggregated.

The behavior of sDPS green sturgeon places them more at risk of entrainment into the hydraulic dredge than salmonids. Sturgeon are benthically-oriented fish, maintaining position on or just above the bottom substrate. This places them within the operating zone of the hydraulic dredge. Sturgeon also tend to preferentially congregate in deep holes or channels where they rest or hold position for long periods of time. These deep holes along the channels of the action area would place congregating sturgeon in the path of the dredging operations. An additional concern is the "lethargic" resting behavior of sturgeon, which could potentially allow the dredges to come within close proximity of the fish prior to eliciting an escape response. Reine and Clarke (1998) reported that white sturgeon on the Columbia River were entrained at an overall rate of 0.015 fish/cubic yard of material dredged, but were entrained in substantial numbers primarily from one location locally known as the "sturgeon hole." These fish ranged in size from 30 cm to 50 cm, which would correspond to juvenile-sized fish. These sizes are similar to those of sDPS green sturgeon that would be expected to be found in the action area.

Dredging will remove benthic invertebrates from the channels within the action area, which represents a loss of forage base to outmigrating salmonids and rearing green sturgeon. The time needed to recolonize the dredged area is unknown and is complicated by the variable maintenance dredging cycles and reach locations. These variable dredging cycles may preclude a "natural climax" benthic invertebrate assemblage from re-establishing itself in a given specific reach of the action area. However, outmigrating salmonids and rearing green sturgeon should be able to find alternative foods and foraging areas outside of the channel and in adjoining channels feeding into the action area. Overall, maintenance dredging is not likely to change the benthic habitat to the extent that listed species would be negatively affected in the reaches to be dredged.

B. Effects on Critical Habitat

The proposed project is likely to result in localized and temporary adverse effects to the designated critical habitat for each of the species considered above. Routine maintenance dredging will prevent future shoaling, continue to remove and expose new horizons of sediment with each dredging cycle, and periodically contribute to the elevated suspended sediment, noise, and contaminant levels in the action area.

The dredged areas will act as a collecting basin for materials carried along by the flow of the Sacramento and San Joaquin rivers. Furthermore, the maintenance of the cross-sectional area of the channel will maintain the artificial volume of the channel compared to that which would naturally occur, and thus is expected to slow down the flushing velocity of the ambient river flow, and allow suspended material to settle out of the water column within the DWSCs. The constant adjusting of the channel cross section from that which normally occurs through equilibrium of the natural energy and sediment budgets to those of the artificially maintained channel dimensions perpetuates the need for dredging and the reduction of flow velocity throughout the channel.

The action area and the Delta in general currently have marginal habitat quality due to anthropogenic alterations over the previous 150 years. These alterations include extensive levee construction, installation of rock slope protection on the levee faces (riprapping) which typically requires the removal of riparian vegetation, dredging of channels to enhance water diversions for agricultural and municipal purposes, straightening of channels to enhance water flow for flood control and water diversion purposes, and the discharge of agricultural and municipal waste effluents into the river channel at numerous locations within the Sacramento and San Joaquin rivers and Delta.

In July, 2005, NMFS' critical habitat analytical review teams (CHARTs) issued their final assessments of critical habitat for 7 listed salmon and steelhead ESUs in California (NMFS 2005d). This included critical habitat descriptions for the Central Valley spring-run Chinook salmon ESU and the CCV steelhead DPS. Section 3 of the ESA (16 U.S.C. 1532(5)) defines critical habitat as "(i) the specific areas within the geographic area occupied by the species, at the time of the listing * * * on which are found those physical and biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection." These features include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of the species. After considering the above features, the CHARTs considered the principal biological or physical features that are essential to the conservation of the species, known as PBFs. The specific PBFs considered in determining the critical habitat for listed salmonids in California include (NMFS 2005b):

1. Freshwater spawning sites with sufficient water quantity and quality and adequate substrate to support spawning, incubation, and larval development.

2. Freshwater rearing sites with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and allow salmonid development and mobility; sufficient water quality to support growth and development; food and nutrient resources such as terrestrial and aquatic invertebrates and forage fish; and natural cover such as shade, submerged and overhanging LWD, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

3. Freshwater migration corridors free of obstruction and excessive predation with adequate water quantity to allow for juvenile and adult mobility; cover, shelter, and holding areas for juveniles and adults; and adequate water quality to allow for survival.

4. Estuarine areas that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to cover juveniles.

5. Marine areas with sufficient water quality to support salmonid growth, development, and mobility; food and nutrient resources such as marine invertebrates and forage fish; and nearshore marine habitats with adequate depth, cover, and marine vegetation to provide cover and shelter.

The CHART indicated in their review (NMFS 2005b) that the Sacramento San Joaquin Delta sub-basin encompasses an area of approximately 446 square miles with 355 miles of stream channels. Of this, fish distribution and habitat use occur in approximately 194 miles of occupied riverine/estuarine habitat for CCV steelhead and 180 miles for the Central Valley spring-run Chinook salmon. The CHART concluded that these occupied areas contained one or more PBFs (*i.e.*, freshwater rearing and migratory habitat and estuarine areas) and described the Delta as having a high conservation value, primarily due to its use as a rearing and migratory corridor for listed spring-run Chinook salmon and steelhead in the Central Valley.

The river channels within the action area are primarily used as a migratory corridor by winter-run, Central Valley spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon moving into and out of the Sacramento and San Joaquin river watersheds. These fish move through the rivers and Delta to the estuaries and bays and the marine waters beyond. Due to the loss of riparian habitat and tidal flats resulting from decades of dredging and riprapping, the ecological value of the lower Sacramento and San Joaquin rivers as rearing habitat has been greatly diminished from historical conditions, although rearing is still considered to occur in the lower rivers and Delta. The CHART has determined that the waterways of the Delta are necessary for connecting the freshwater spawning habitats upstream in the Sacramento and San Joaquin river watersheds with the downstream waterways leading to the ocean and, thus, have a high conservation value. The proposed project itself will not significantly diminish the value of the waterways through the Delta as a migratory corridor compared to its current condition.

The long-term effects of bank stabilization activities will be to maintain the currently channelized and riprapped conditions characterizing the banks of the DWSCs. These conditions will be periodically worsened as the limited riparian vegetation that may be present is removed to facilitate replacement of riprap. In general, the DWSCs will continue to provide relatively uniform, deep, open habitat that lacks the suitable shallow water resting, sheltering, and feeding locations which characterize the freshwater rearing sites (a PBF of critical habitat) on which juvenile sturgeon, steelheads and other salmonids depend for adequate growth and protection from predators. The reduction in shade may contribute to elevated water temperatures in the upper sections of the DWSCs, but this should not be of great concern because those reaches are distantly removed from the principal route of the migratory corridor for listed juvenile salmonids and sturgeon. Green sturgeon may be less affected by these conditions as they tend to occupy deep pools. Although the proposed project will prevent the Sacramento and San Joaquin rivers from reestablishing natural hydrological conditions and characteristics, it is not anticipated to further degrade an already highly degraded system. It should be noted, however, that implementation of the proposed project over a 10-year period will also have the effect of contributing to the maintenance of the baseline condition in its currently degraded state, thereby temporally impeding the restoration of critical habitat function and value by natural processes.I

C. Effects on Listed Species Likelihood of Survival and Recovery

NMFS anticipates that the proposed project will result in the exposure of a small number of listed salmonids to negative effects from increased levels of turbidity and suspended sediment, contaminants, entrainment, habitat loss, and bank stabilization. Exposed individuals are expected to be primarily outmigrating juveniles and smolts. Adult and juvenile steelhead are expected to be present in the action area primarily during late November and December. Similarly, NMFS does not expect that juvenile winter-run Chinook salmon will be present in the action area until late in the dredging work window. Fish exposure to DMPS effluent will be intermittent and based on local hydrology, tides, and the spatial and temporal position of migrating fish. The preceding information indicates overall that exposure of listed salmonids to effluent from the DMPS sites should be infrequent and involve very few individuals, although decant water can continue to discharge for several days to weeks from the DMPS following the cessation of active dredging during October and November. The elevated stress levels and contaminants may degrade the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predation.

NMFS does not anticipate that Central Valley spring-run Chinook salmon adults will occur in the action area during the dredging work window or soon after its closure, and therefore are not likely to be directly affected by activities such as the dredging or bank stabilization activities. Also, the likelihood of juvenile spring-run Chinook salmon being present in the action area during the dredging work window is low. Yearling fish may appear in the action area as early as late October, but are not likely to occur in any substantial numbers until after February when the pulse of emigrating juvenile spring-run Chinook salmon begin to enter the action area. The exposure potential of spring-run Chinook salmon to the decant water is expected to involve few fish, as the DMPS are expected to have drained prior to the major influx of juveniles into the waters of the action area, unless there is substantial winter precipitation.

For all three of the listed salmonid species, no spawning or major freshwater rearing habitat will be affected by the proposed activities, so impacts on spawning survival and survival from egg to smolt are not expected. The very small loss of juveniles and smolts anticipated would be unlikely to result in a change in adult returns, because the number expected to be lost is small in comparison to the number produced and likely to survive to become adults.

sDPS green sturgeon are expected to be more vulnerable than salmonids to the negative effects of dredging due to their benthic-oriented behavior which conceivably put them in closer proximity to the contaminated sediment horizon, although it is presently unclear if juveniles exhibit this behavior to the same extent that adults do. Their "inactive" resting behavior on substrate has the potential to put them in dermal contact with contaminated sites which can lead to lesions and the production of tumors from materials in the substrate. Sturgeon are also benthic invertebrate feeders that forage on organisms that can sequester contaminants at much higher levels than the ambient water or sediment content, such as the Asian clams *Corbicula* and *Potamocorbula* that are prevalent in the action area. The great longevity of sturgeons also places them at risk for the bioaccumulation of contaminants to levels that create physiologically adverse conditions within the body of the fish. Because they prefer deep pools, green sturgeon may have some reduced risk of exposure to effluent from DMPS, which will be released in the shallow water margins of the river channel.

Little is known about the migratory habits and patterns of either adult or juvenile green sturgeon in the Delta region. The extent and duration of rearing in the Delta is unclear (i.e., months to years), but NMFS believes that juvenile green sturgeon, including sub-adults, could be found during any month of the year within the waters of the Delta. Therefore, both adult and juvenile green sturgeon have the potential to be negatively affected by exposure to contaminants, and entrainment due to the proposed project. These fish are likely to be in the vicinity of the most downstream reaches of the proposed dredging, DMPS, and bank stabilization sites year-round.

Due to the lack of population abundance information regarding the sDPS green sturgeon, a variety of estimates must be utilized to determine the range of effects resulting from the take of a small number of green sturgeon. Compared to the estimated population sizes suggested by the CDFW tagging efforts (CDFG 2002), juvenile and sub-adult captures passing RBDD, and past IEP sampling efforts, take in the form of exposure to elevated levels of contaminants and re-suspended sediments, migration delays, physical injury, and mortality of both adult and juvenile sDPS green sturgeon is expected to represent a relatively small proportion of the standing populationin the Sacramento River watershed..

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed project, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed project is not likely to jeopardize the continued existence of winter-run, Central Valley spring-run Chinook salmon, CCV steelhead, or the sDPS green sturgeon, nor destroy or adversely modify any of their designated critical habitats.

2.8 Incidental Take Statement

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

2.8.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:
NMFS anticipates that the proposed Sacramento and Stockton DWSC Maintenance Dredging and Bank Protection project and the associated shipping activities will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon. The incidental take is expected to be in the form of death, injury, harassment, and harm from sources such as turbidity and contaminant resuspension, entrainment in the dredge, exposure to DMPS effluent, and altered habitat conditions. Direct take of salmonids from the Corps' dredging activities (*e.g.*, entrainment in the dredge or exposure to re-suspended contaminants) is expected to occur primarily to adult and juvenile California Central Valley steelhead, juvenile Sacramento winter-run Chinook salmon, and yearling Central Valley spring-run Chinook salmon during the period from September 1 through November 30, when the start of winter rains may trigger the migration of a small number of these fish through the most downstream portions of the action area. Take from exposure to the DMPS effluent may continue to occur from the time shortly after dredging operations and dredged material placement begins in August each year, through the month of January after the decant water from the last DMPS to receive dredged material that year has had sufficient time to drain back into the receiving waters of the Delta

where they will mix and gradually dissipate into background conditions over time. Take from long-term impacts or changes to the action area (*e.g.*, loss of shallow water and riparian habitat in areas of bank stabilization) is expected to occur annually over a 10-year period on a seasonal basis whenever individuals from one or more of the listed ESUs or DPSs are present in the action area.

NMFS assumes that like Chinook salmon and steelhead, adult and sub-adult sDPS green sturgeon are most likely to occur in the most downstream reaches of the DWSC which is part of their major migration route. Juvenile green sturgeon may be present anywhere in the action area at any time of the year, however, since they may spend up to 4 years rearing in the Delta. Green sturgeon are expected to occur in the action area year-round, although in greater numbers from April through October. Therefore, take from the proposed project is most likely to occur from June through October, due to overlap with the proposed work windows for maintenance dredging and bank protection activities. The occupation of benthic habitat by green sturgeon is expected to increase their vulnerability to entrainment by the dredge cutterhead compared to listed salmonids.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS green sturgeon taken will be difficult to quantify because dead, injured, or impaired individuals will be difficult to detect and recover. Take is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and sDPS green sturgeon juveniles harmed, harassed, or killed from altered habitat conditions caused by the maintenance dredging of the Sacramento and Stockton DWSC or bank protection and levee stabilization activities within the action area. Such conditions may include loss of benthic organism diversity, loss of riparian and shallow water habitat, reduced growth rate, or increased predation risk. Altered habitat is not expected to exceed the footprint of the maintenance dredging or bank stabilization areas as described in the project description included in the BA. Values will change according to the determination of which specific activities are necessary and achievable during annual coordination between NMFS and the Corps each year.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and sDPS green sturgeon juveniles and adults that are harmed or killed from exposure to contaminants re-suspended during the maintenance dredging action, and the subsequent discharging of decant water from DMPSs identified in the project description that are approved to receive the spoils from dredging operations. NMFS anticipates that take of listed salmonids, whether in the form of mortality or morbidity, will occur from contaminant re-suspension. The anticipated level of contaminant-related mortality is expected to be higher than the mortalities incurred from habitat effects. However, except for the month of November, very few listed salmonids are expected to be present in the action area during the dredging work windows (August 1 through October 31 in the Sacramento DWSC and August 1 through November 30 in the Stockton DWSC), based on salmon monitoring activities conducted

by the CDFW and USFWS in the Sacramento / San Joaquin River Delta for winter-run and spring-run Chinook salmon. Take may be estimated from the initial zone of dilution for each DMPS outfall (300 feet total length up and downstream from the outfall and not to exceed half the width of the receiving water body outwards from the bank). Based on the annual juvenile production estimate calculated by NMFS in recent years, a conservative estimate of the number of juvenile winter-run Chinook salmon surviving to the Delta might approach 200,000 fish. Considering the limited number of these individuals that might enter the Delta before the end of November, NMFS estimates that roughly 5%, or approximately 10,000 fish, could be present in the action area during the proposed dredging activities. Of these, the average number of winter-run sized juvenile Chinook salmon that may potentially be exposed to the decant effluent during the 3 months from September to November is approximately 500 fish, or 5% of the fish in the action area during the proposed dredging activities, of which 2 percent are expected to suffer morbidity and mortality (10 fish). Based on the same reasoning, approximately 200 spring-run sized juvenile Chinook salmon could be exposed in late November. Of these exposed fish, 2 percent are expected to suffer morbidity or mortality from the dredging action's discharge of decant waters from the DMPSs (4 fish). Estimating the number of juvenile CCV steelhead potentially exposed to the effects of the action is more difficult, as the timing and proportion of juveniles entering the Delta from either the Sacramento or San Joaquin river basins is not precisely known. However, based on estimates derived from rotary screw traps and weir counts on the various tributaries that produce CCV steelhead in the two river systems, incidental take of CCV steelhead is not expected to exceed 4 fish, or approximately 2 percent of the population present in the action area during the dredging season of any given year covered by this biological opinion.. NMFS recently completed a 5-year status review of the sDPS of North American green sturgeon (NMFS 2015) in which capture rates of adult and subadult green sturgeon present in the San Francisco Bay Estuary for the 10-year period of 2005-2014 were summarized along with the results from five years of DIDSON surveys (2010-2014) conducted in the Sacramento River to estimate the green sturgeon spawning run size. Based on those findings, approximately 315 juvenile or adult North American green sturgeon are anticipated to be present in the action area on an annual basis during the proposed project and potentially exposed to re-suspended contaminants resulting from implementation of the proposed project. The sampling in the San Francisco Bay Estuary occurs during the months of August through October, and therefore, greatly overlaps with the proposed dredging activities. In the absence of definitive data, NMFS estimates that the number of sDPS green sturgeon taken by the proposed activities in the action area will be roughly equal to the average number of sturgeon captured in the Bay Delta and Estuary through the surveys and sampling methods described above. Therefore, annual incidental take is estimated to be 315 juvenile, sub-adult, or adult North American green sturgeon per year, of which 2 percent are expected to suffer morbidity and mortality (6 fish).

3. All fish entrained into the hydraulic dredge during its operation are expected to suffer 100 percent mortality, as they will end up in the DMPS following entrainment. Incidental take of juvenile North American green sturgeon is expected to be relatively high (*i.e.*, 10 percent of those exposed) due to their benthic orientation, which will make direct

exposure to the dredge cutterhead more likely. Annual incidental take of juvenile sDPS green sturgeon is not expected to exceed 5 fish, based on the average capture rate of juvenile and adult green sturgeon observed by CDFW in their annual surveys from August through October in the San Francisco Bay Delta Estuary (NMFS 2015).

2.8.2 Effect of the Take

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

2.8.3 Reasonable and Prudent Measures

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

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon.

1. Measures shall be taken to avoid, minimize, and monitor the impacts of maintenance dredging upon listed salmonids, sDPS green sturgeon, and their designated critical habitats.

2. Measures shall be taken to avoid, minimize, and monitor the impacts of bank stabilization activities upon listed salmonids, sDPS green sturgeon, and their designated critical habitats.

3. Measures shall be taken to monitor the impacts to listed sDPS green sturgeon from entrainment into the hydraulic dredge during its operation.

2.8.4 Terms and Conditions

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

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

   a. Dredging operations shall be conducted within the specified work windows of August 1 through October 31 in the Sacramento DWSC and August 1 through

November 30 in the Stockton DWSC. If dredging is necessary outside of these windows, NMFS shall be contacted, in writing, for approval at least 30 days prior to the activity. The request must include the location and size of the work area within the DWSCs, estimates of the amount of time required and dredging material to be removed, and most recent monitoring data indicating the likely presence and magnitude of listed anadromous fish species in the action area. The request is to be sent to the following address:

National Marine Fisheries Service
California Central Valley Office
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4706

b. The Corps shall visually monitor the waterway adjacent to the dredge area (*i.e.*, within 300 feet) during all dredging operations for any affected fish including, but not limited to, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the sDPS of North American green sturgeon. Observation of one or more affected fish will be reported to NMFS by telephone at (916) 930-3600, by FAX at (916) 930-3629, or at the address given above within 24 hours of the incident. Dredging operations shall be halted immediately until the Corps coordinates with NMFS to determine the cause of the incident and whether any additional protective measures are necessary to protect listed salmonids and green sturgeon. Any protective measures that are determined necessary to protect listed salmonids and sturgeon shall be implemented as soon as practicable within 72 hours of the incident. Affected fish are defined as:

1. Dead or moribund fish at the water surface;
2. Showing signs of erratic swimming behavior or other obvious signs of distress;
3. Gasping at the water surface; or
4. Showing signs of other unusual behavior.

c. Prior to each dredging season, the Corps shall provide NMFS documentation of exact reaches of the DWSCs proposed for maintenance dredging, schedules for that dredging year, and which DMPS are to be used. Dredging operations shall not commence until NMFS has confirmed receipt of this documentation and concurred that the planned activities comport with this programmatic opinion. At the completion of each dredging season, the Corps shall provide NMFS documentation of the exact reaches of the DWSCs that were dredged, and which DMPSs were used. Also, NMFS shall be sent copies of any sediment, effluent, or water quality monitoring reports required by the Regional Board that are related to the dredging actions of this project at the address given above within 60 days of their completion.

d. By August 1, 2016, the Corps shall submit to NMFS the finalized fish community, entrainment, and water quality monitoring reports summarizing the monitoring results from the 2013 – 2015 dredging seasons. As these reports were part of non-discretionary terms and conditions from both the April 4, 2006, and August 29, 2006 section 7 consultations on the Stockton Deep Water Ship Channel Maintenance Dredging and Levee Stabilization and Sacramento Deep Water Ship Channel Maintenance Dredging and Bank Protection projects, respectively, they would have helped considerably in the analysis of effects for the currently proposed project. To that end, the Corps shall not begin implementing the Sacramento and Stockton Deep Water Ship Channels Maintenance Dredging and Bank Protection Project until NMFS has received, reviewed, and e-mailed confirmation of the receipt and acceptance of the finalized monitoring reports referenced above.

e. The Corps shall continue to perform entrainment monitoring during annual maintenance dredging for the duration of the proposed project, and submit an annual report by June 1 of each year summarizing the results of the previous year's effort to NMFS at the address given above.

2. The following term and condition implements reasonable and prudent measure 2:

a. The conceptual models of the Standard Assessment Methodology (SAM) shall be applied to the proposed project to design specific bank stabilization activities that will minimize impacts to listed species. The SAM was developed by the Corps, in collaboration with NMFS, CDFW, DWR, and the FWS, to quantify impacts to listed fish species and their habitat from large bank protection projects. The SAM represents the best available scientific approach for assessing the effects of bank protection actions to listed anadromous fish and their habitat. The Corps shall submit the SAM model results to NMFS for review prior to the commencement of bank stabilization activities for each year of the period covered by this biological opinion. The Corps shall also provide in kind compensatory mitigation at a ratio of 3:1 for the maximum SAM deficits at each seasonal water surface elevation.

3. The following term and condition implements reasonable and prudent measure 3:

a. The Corps shall conduct a study to investigate the feasibility of mounting one or more Dual Frequency Identification Sonar (*i.e.*, DIDSON) cameras on the underside of the dredging platform, or perhaps on the swing arm of the dredge itself, in order to evaluate the potential of this technology to monitor and assess the behavioral response of sturgeon, and other demersal species, to the approach of the dredging apparatus, and the cutterhead of the dredge in particular. The pilot study should be completed with a report summarizing the findings submitted to NMFS at the address given above by August 1, 2021.

2.9 Conservation Recommendations

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

1. The Corps should support and promote aquatic and riparian habitat restoration within the Sacramento / San Joaquin River Delta, and encourage its contractors to modify operation and maintenance procedures through the Corps' authorities in order to avoid or minimize negative impacts to salmonids and sturgeon in this region.

2. The Corps should provide funding to support anadromous fish monitoring programs throughout the Sacramento / San Joaquin River Delta to improve the understanding of migration and habitat utilization by salmonids and sturgeon in this region.

3. The Corps should provide funding to support the maintenance of the acoustic receiver array in the Sacramento / San Joaquin River Delta and the San Francisco Bay-Delta Estuary, which is currently operated and maintained by the University of California at Davis (UCD).

4. The Corps should coordinate with the Interagency Ecological Program (IEP) to further evaluate the ecosystem function of the Sacramento DWSC and the Port of West Sacramento and consider developing a study to re-operate the Jefferson Ship Locks to enhance fish passage for salmon, steelhead and sturgeon and estuarine habitat values.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

2.10 Reinitiation of Consultation

This concludes formal consultation for the Sacramento and Stockton Deep Water Ship Channel Maintenance Dredging and Bank Protection Project.

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

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

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 U.S. Army Corps of Engineers (Corps) and descriptions of EFH for Pacific coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), and Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The Corps has determined that the proposed project will adversely affect the EFH for federally managed fish species within the Pacific coast groundfish fishery management plan (FMP), the Pacific coast salmon FMP, and the coastal pelagic species FMP, including the estuarine habitat area of particular concern, defined as the upriver extent of saltwater intrusion where ocean-derived salts measure less than 0.5 parts per thousand during the period of average annual low flow.

3.2 Adverse Effects on Essential Fish Habitat

Both the bank protection activities and the maintenance dredging of the Sacramento and Stockton deep water ship channels will adversely affect EFH through the re-suspension of sediments potentially resulting in temporary (1) increases in turbidity, (2) reductions of prey availability, and (3) increased levels of re-suspended contaminants. These effects have been described in greater detail in Section 2.4 (Effects of the Action) of the preceding biological opinion.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS incorporates the terms and conditions 1.a. and 2.a. from Section 2.8 (Incidental Take Statement) of the preceding biological opinion as conservation recommendations that are appropriate and necessary to address the adverse effects to EFH described in Section 3.2, above.

Fully implementing these EFH conservation recommendations would protect designated EFH for Pacific coast salmon, Pacific coast groundfish, and coastal pelagic species.

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 Corps have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the 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 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.

4.1 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 United States Army Corps of Engineers. Individual copies of this opinion were provided to the United States Army Corps of Engineers. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 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.

4.3 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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