UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404

July 9, 2015 **In response refer to:** WCR-2014-1599

Lieutenant Colonel John C. Morrow
Department of the Army
San Francisco District
U.S. Army Corps of Engineers
1455 Market Street
San Francisco, California 94103-1398

Jane Diamond
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Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, California 94105-3901

Dear Colonel Morrow and Ms. Diamond:

Thank you for your letter of October 2014, regarding the programmatic consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.), for the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS).

NMFS completed formal consultation with the Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) during the adoption of the LTMS Program in 1998, and NMFS issued a biological opinion and incidental take statement on September 18, 1998. Since that time our agencies have worked together to further reduce the potential impacts of San Francisco Bay dredging projects on listed fish, to streamline the regulatory process, and reduce agency and dredge project sponsor workloads. The updated project description provided by the Corps and EPA in October 2014 reflects the successes of the LTMS Program to date, conditions that have changed since the 1998 consultation, and new measures to continue the protection and enhancement of conditions for listed fish and their habitat throughout the San Francisco Bay Region.

The enclosed biological opinion is based on our review of the proposed changes to the LTMS Program and replaces the September 18, 1998 biological opinion. The biological opinion describes NMFS' analysis of the potential effects of dredging and disposal projects conducted throughout the San Francisco Bay Region under the LTMS Program on threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*), threatened California Central Valley steelhead (*O. mykiss*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), endangered Sacramento River winter-run Chinook salmon (*O. tshawytscha*), threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for green sturgeon, CCC steelhead, and winter-run Chinook salmon in accordance with section 7 of the ESA. CCC coho salmon (*Oncorhynchus kisutch*) was included in the 1998 NMFS biological opinion, but current information indicates this species has be extirpated from San Francisco Bay and its tributary streams. Based on the NMFS review of the updated LTMS Program, the proposed action is expected to have no effect on CCC coho salmon or its designated critical habitat.

In the enclosed biological opinion, NMFS concludes the project is not likely to jeopardize the continued existence of these listed salmonid species or green sturgeon. NMFS has also concluded the proposed project is not likely to result in the destruction or adverse modification of the critical habitats described above. However, NMFS anticipates take of listed salmonids will occur from entrainment and degradation of water quality during dredging and disposal activities. An incidental take statement, which applies to implementation of the LTMS Program with non-discretionary terms and conditions, is included with the enclosed biological opinion.

The biological opinion will be available through NMFS' Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts][1]. A complete record of this consultation is on file at the NMFS North-Central Coast Office in Santa Rosa, California.

Please contact Sara Azat at 707-575-6067 or Sara.Azat@noaa.gov if you have any questions, or if you require additional information regarding this biological opinion.

Sincerely,

[signature] for

William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Cynthia Jo Fowler, Corps San Francisco District
Brian Ross, EPA, San Francisco
Brenda Goeden, BCDC, San Francisco
Elizabeth Christian, SFB Reg. Water Board, Oakland
Jim Starr, CDFW, Stockton

[1] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR 2014-1599.

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

Long Term Management Strategy
For the Placement of Dredged Material in the San Francisco Bay Region

NMFS Consultation Number: WCR-2014-1599

Action Agency: Army Corps of Engineers, San Francisco District and U.S. Environmental Protection Agency, Region IX.

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or 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	No	No
Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No
Sacramento River Winter-run Chinook (*O. tshawytscha*)	Endangered	Yes	No	No
Central Valley Spring-run Chinook (*O. tshawytscha*)	Threatened	Yes	No	No
North American Green Sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No

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

Issued By: [signature] for

William W. Stelle, Jr.
Regional Administrator

Date: July 9, 2015

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LIST OF ACRONYMS

BA	Biological Assessment
BCDC	Bay Conservation and Development Commission
BMP	Best Management Practices
BOR	Bureau of Reclamation
BRT	Biological Review Team
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
CSLC	California State Lands Commission
Corps	U.S. Army Corps of Engineers
CV	Central Valley
cy	cubic yards
cy/yr	cubic yards per year
dB	decibel
DDT	dichlorodiphenyltrichloroethane
DPS	distinct population segment
DWR	Department of Water Resources
DQA	Data Quality Act
EFH	essential fish habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	evolutionary significant unit
FEIR	Final Environmental Impact Report
FMP	Fishery Management Plan
FRH	Feather River Hatchery
ft	foot
FWS	United States Fish and Wildlife Service
GCID	Glenn Colusa Irrigation District
ITS	incidental take statement
MHHW	mean higher high water
MISP	Marine Invasive Species Program
MLLW	mean lower low water
mm	millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MOTCO	Military Ocean Terminal
NMFS	National Marine Fisheries Service
NTU	nephlometric turbidity units
PCE	primary constituent element
RBDD	Red Bluff Diversion Dam
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
TL	total length
TMDL	Total Maximum Daily Load
USFWS	United States Fish and Wildlife Service

1.0 INTRODUCTION

1.1 Background

In response to growing concerns over direct, indirect, and cumulative effects of dredging and dredged material disposal activities on the aquatic environment of the San Francisco Bay/Estuary, Federal and state agencies joined with navigation interests, fishing groups, environmental organizations, and other interested parties to develop the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS Program). The San Francisco Bay LTMS Program is a cooperative effort of the U.S. Army Corps of Engineers (Corps), U.S. Environmental Protection Agency (EPA), the San Francisco Bay Regional Water Quality Control Board (Water Board), San Francisco Bay Conservation and Development Commission (BCDC), and State Water Resources Control Board (SWRCB) (herein after referred to as LTMS agencies).

In 1998, the LTMS agencies completed the Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report (Programmatic EIS/EIR), selecting the new long-term plan for reducing disposal within San Francisco Bay over time, and increasing recycling of dredged material for "beneficial uses" including habitat restoration, levee maintenance, and construction fill. The San Francisco Bay LTMS is designed to develop technically feasible, economically prudent, and environmentally acceptable long-term solutions to the disposal of dredged material over a fifty year period. It specifically addresses maintenance dredging, and is not intended to address new dredging or sand mining. The primary goals of the LTMS includes managing dredging and disposal in an economically and environmentally sound manner, maximizing the use of dredged material for beneficial reuse, and developing a coordinated permit application review process for dredging and disposal projects.

During the development of the LTMS Program, the LTMS agencies worked with the California Department of Fish and Wildlife (CDFW, previously referred to as California Department of Fish and Game), the U.S. Fish and Wildlife Service (USFWS), and NOAA’s National Marine Fisheries Service (NMFS) to develop measures to avoid and minimize the potential impacts of dredging and disposal projects. One of the primary tools used to avoid and minimize the potential adverse effects of dredging and in-bay disposal was environmental work windows. Environmental work windows are established periods within the calendar year that avoid or minimize overlap with the presence of a target species or a sensitive life stage of a target species. For certain species listed under the Endangered Species Act of 1973, as amended (ESA), and some non-listed species of special concern, environmental work windows were incorporated into the LTMS Program. During environmental work window periods, dredging and disposal activities are restricted in specific areas to protect listed species and species of special concern.

As early as 2001, the Corps, EPA, and NMFS began to discuss difficulties associated with the environmental work windows. Both the Corps’ dredging program for federal navigation channels as well as small dredging projects by industry, municipalities, and private businesses were having problems accomplishing all their maintenance dredging projects within the established work windows. Frequent requests to work outside the LTMS windows were submitted to NMFS for review and there became a need to develop mitigation actions for dredge projects that must work outside the established windows.

In June 2006, NMFS listed the southern distinct population segment (DPS) of North American green sturgeon as a threatened species under the ESA and in March 2009, the State of California listed longfin smelt (*Spirinchus thaleichthys*) as a threatened species under the California Endangered Species Act (CESA).

1.2 Consultation History

On February 18, 1998, the EPA initiated consultation with NMFS pursuant to section 7 of the ESA for the proposed adoption of the LTMS Program. The LTMS Program proposed to avoid and minimize adverse effects to listed anadromous salmonids by restricting dredging and the associated disposal of dredge materials to periods when the likelihood of listed anadromous salmonids presence in San Francisco Bay was low (i.e., environmental work windows). Appendix J of the LTMS Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR) presents the environmental work windows by species and location. NMFS, the Corps and EPA agreed during consultation that all dredge projects would adhere to these work windows. If a project was unable to restrict dredging or disposal to the environmental work window for listed anadromous salmonids, the Corps would conduct a separate, project-specific, section 7 consultation with NMFS.

A draft biological opinion/conference opinion and incidental take statement was provided by NMFS to EPA on August 19, 1998. Comments were provided by EPA and on September 18, 1998, NMFS issued a biological and conference opinion to EPA that addressed potential impacts to listed and proposed salmonids and to their designated critical habitat. The biological opinion concluded that dredging activities conducted in accordance with the 50-year LTMS Program would not likely jeopardize the continued existence of the following anadromous salmonid species: (1) endangered winter-run Chinook salmon; (2) threatened Central California Coast coho salmon; (3) threatened Central California Coast steelhead; (4) threatened California Central Valley steelhead; (5) proposed-threatened Central Valley fall/late-fall run Chinook salmon; (6) proposed-threatened Southern Oregon/California Coastal fall-run Chinook salmon; and (7) proposed-endangered Central Valley spring-run Chinook salmon.

By letter dated January 16, 1999, to NMFS, EPA clarified the following points regarding the LTMS Program addressed in the 1998 consultation with NMFS: (1) only dredging and disposal for navigational projects are included; (2) NMFS participation in the Dredge Materials Management Office does not require entering the interagency Memorandum of Understanding; (3) correction of a typographical error regarding the biological opinion and Table J-2 of the LTMS Final EIS/EIR; and (4) the Corps shall be included as a consulting agency under the LTMS Program's biological opinion.

By letter dated August 13, 2004, to NMFS, EPA and the Corps requested two modifications to the environmental work windows for the LTMS Program: (1) South San Francisco Bay work window would be from June 1 to November 30; and (2) Napa River, Petaluma River, and Sonoma Creek work windows would be from July 1 to October 31. NMFS informed EPA and the Corps that these environmental work windows were generally consistent with the September 19, 1998 biological opinion and incidental take statement.

During the latter half of 2004, NMFS actively solicited information regarding the status of North American green sturgeon (*Acipenser medirostris*) for the purpose of updating the NMFS' 2002 risk assessment for this species. The NMFS Biological Review Team (BRT) completed an updated status review in February 2005 and it was submitted to NMFS Regional Offices for further consideration. On April 6, 2005, NMFS published a proposed rule to list the southern DPS of North American green sturgeon as a threatened species (70 FR 17386). On April 4, 2006, NMFS published the final rule listing the southern DPS of green sturgeon as a threatened species (71 FR 17757).

By letter dated November 29, 2006, NMFS requested the Corps and EPA provide information regarding the following topics: (1) characteristics of maintenance dredge sites; (2) characteristics of San Francisco Bay Region areas that are not being dredged; (3) in-bay disposal sites; (4) potential entrainment risk of listed species by large suction dredges; (5) natural and anthropogenic contaminants in dredged sediment; and (6) activity of large vessels that transit San Francisco Bay. On February 13, 2007, the Corps provided the requested information, less the information regarding large vessel activity. In April 2007, the Corps provided the vessel traffic data to NMFS.

On May 24, 2007 a conference call with representatives from NMFS and Corps discussed environmental work windows and measures for the protection of green sturgeon. The group reviewed the results of acoustic tag detections of sturgeon in the vicinity of the Richmond Harbor.

On January 28, 2008 the Corps provided NMFS an analysis regarding green sturgeon movements in relation to Corps dredging projects. The analysis utilized the results of acoustic tag detections of green sturgeon and concluded that the species spend 77 percent of their time in shallow water and are not likely to be present at the deeper in-bay aquatic disposal sites.

On November 20, 2008, NMFS, EPA and the Corps meet in San Francisco to discuss the effects of LTMS dredging projects on green sturgeon.

EPA submitted draft project description of the current LTMS Program to NMFS in June 2009.

On February 24, 2010, representatives of NMFS, Corps and EPA met to discuss the measures under development for the programmatic consultation for Essential Fish Habitat (EFH) pursuant to the Magnuson Stevens Fishery Conservation and Management Act (MSA), and the relationship to the reinitiated ESA consultation for listed species. In February 2010, the Corps provided detailed information to NMFS regarding the location and volume of dredging performed in federal navigation channels which occurred outside of the environmental work windows.

A meeting was held on March 26, 2010 with representatives of NMFS, Corps, EPA and BCDC to discuss environmental work windows, monitoring, research and green sturgeon. In particular, NMFS requested information from the Corps regarding the monitoring of water quality at dredging and disposal sites. Discussions on these topics continued by conference call on March 29, 2010, at a April 13, 2010 meeting, and at a April 27, 2010 meeting.

During 2011 and 2012, the Corps worked with CDFW staff to develop measures to avoid and reduce impacts to State-listed longfin smelt. NMFS participated in several conferences calls regarding this topic to gain a better understanding of the fisheries issues associated with the Corps' dredging equipment and collaborate on measures to reduce impacts associated with dredging. NMFS and CDFW coordination also ensured measures to avoid and reduce impacts to longfin smelt did not inadvertently cause harm to listed salmonids or green sturgeon.

On March 29, 2012, NMFS attended the LTMS Program 12-year review meeting with representatives from Corps, EPA, Water Board, BCDC, and various dredging stakeholder groups. The meeting provided a summary of the first 12 years of implementation of the LTMS Program.

Representatives of NMFS, Corps, EPA, BCDC, and the Water Board met on October 16, 2012, to update the LTMS project description and evaluate the program's environmental work windows. This group continued work in 2012 to simplify the work window requirements and develop mitigation for dredging projects that must work outside the environmental work windows.

In February 2013, the Regional Water Board and the Corps announced their intent to prepare a joint Environmental Assessment and Environmental Impact Report for the operation and maintenance of federal navigation channels in San Francisco Bay, consistent with the LTMS Program (Federal Navigation Channels EA/EIR). NMFS, EPA, and the Corps agreed that the reinitiated LTMS consultation with NMFS should be coordinated with this environmental review process to ensure consistency in the measures adopted to protect the state-listed longfin smelt. Coordination between representatives with NMFS, Corps, EPA, BCDC, CDFW, and the Regional Water Board continued in 2013 regarding the project schedule, modification of the LTMS environmental work windows, and fisheries measures for the Federal Navigation Channels EA/EIR.

From December 2013 through March 2014, representatives from the Corps, NMFS, EPA, BCDC, and the Water Board drafted a proposal that would allow for some dredging to occur outside the environmental work windows provided certain measures and mitigation actions are taken. This proposal was presented to the San Francisco Bay dredging stakeholder community at a LTMS Management Committee meeting on April 30, 2014. The proposal was generally well received by stakeholders and the LTMS agencies were encouraged to adopt this plan. Stakeholder comments were solicited and the final plan for updating the LTMS Program with these measures was submitted to NMFS by joint letter from EPA, dated October 8, 2014, and Corps, dated October 14, 2014. For purposes of the reinitiated section 7 consultation with NMFS, the October 2014 letter and plan constituted the final project description for the updated LTMS Program.

Via email message dated November 17, 2014, EPA provided to NMFS a clarification regarding the term “clamshell” in the final project description. The term “clamshell dredge” was used under the “Best Practices” section of paragraph 2(a) of the October 2014 project description. EPA requested “mechanical” be used in place of “clamshell” because there are some dredgers that use an excavator or other mechanical equipment that are not considered a “clamshell” dredge.

1.2.1 LTMS Actions Following the Issuance of the September 18, 1998 Biological Opinion

Following the issuance of the NMFS biological opinion in 1998, the LTMS agencies developed specific guidance for implementing the strategy selected in the program’s Policy Environmental Impact Statement/Programmatic Environmental Impact Report and this program guidance was presented in the 2001 LTMS Management Plan (Management Plan). The LTMS is a 50-year plan that covers all federal and non-federal operations and maintenance dredging and dredged material placement in the region. To allow time for planning, budgeting, and creating alternatives to in-Bay disposal, the Management Plan established a 12-year transition period for achieving the reduced in-Bay disposal goal of 1.25 million cubic yards (plus 250,000 cubic yards contingency) annually. The transition period’s disposal volume limits were voluntary as long as in-Bay goals were met overall. The 12-year transition period was completed in 2012 and the LTMS agencies issued a 12-Year Review Report in August 2012 (LTMS 2012).

1.2.1.1. Dredged Material Management Office

The Management Plan also formalized the Dredged Material Management Office (DMMO) for the purpose of providing a coordinated review of dredging and dredged material disposal project proposals. The DMMO is a joint program with representation from the Corps, EPA, BCDC, and Regional Water Board, and State Lands Commission. NMFS, California Department of Fish and Wildlife, and U.S. Fish and Wildlife Service are encouraged to participate at DMMO meetings as commenting resource agencies. Since implementation of the LTMS, the DMMO serves as a single point-of-entry into the state and federal regulatory process for dredge project applicants. The DMMO does not issue permits; rather it makes consensus-based recommendations to the member agencies on the completeness of permit applications, adequacy of sediment sampling and analysis plans (SAP), and suitability of sediments for proposed disposal locations.

1.2.1.2 LTMS Studies and Literature Reviews

To improve the scientific understanding of listed fish species in San Francisco Bay and the potential impacts to these species from dredging, the LTMS Program has funded a number of studies, intended to help address the basis of some of the existing work windows with an eye toward whether they could be modified to allow dredging for longer periods in some locations. The LTMS environmental work window Science Framework was developed, with input from NMFS and the other resource agencies, to identify agency concerns and potential studies that may be able to address those concerns. The LTMS Program went on to undertake a number of the identified studies, including both literature reviews and laboratory and field studies. The completed and draft studies that perform by and in conjunction with the LTMS Program in San Francisco Bay are listed in Table 1. Since 2011-12, funding has been nearly eliminated and consequently additional scientific studies have been put on hold.

Table 1. LTMS-Associated Scientific Studies, Literature Reviews and Symposia

Completed Studies and Report
Sediment
Framework for Assessment of Potential Effects of Dredging on Sensitive Fish Species in San Francisco Bay. August 2004
Spatial Characterization of Suspended Sediment Plumes During Dredging Operations Through Acoustic Monitoring (Oakland Outer Harbor). January 2004.
Suspended Sediment Plumes Associated with Mechanical Dredging at the Port of Oakland, California. 25th Annual WEDA Conference, 2005.
Characterization of Suspended Sediment Plumes Associated with Knockdown Operations at Redwood City, California. October 2005.
Anadromous Salmonids
Young Salmonid Out-Migration Through San Francisco Bay with Special Focus on their Presence at the San Francisco Waterfront. May 2011.
Inter-annual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook Salmon (*Oncorhynchus tshawytshca)* and steelhead trout (*Oncorhynchus mykiss).* May 2012.
Juvenile Salmonid Outmigration and Distribution in the San Francisco Estuary: 2006-2008 Interim Draft Report. January 2010.
Longfin Smelt
LTMS Longfin Smelt Literature Review and Study Plan. August 2011.
Entrainment of Smelt in San Francisco Bay by Hydraulic Dredges: Rates, Effects, and Mitigation. October 2013.
Longfin Smelt Monitoring During Dredging of the Pinole Shoal Channel in San Pablo Bay, California in June 2010. July 2010.
2011 Longfin Smelt Monitoring During Dredging By the USACE Hopper Dredge Essayons In the San Francisco Bay Area. December 2011.
Herring
A Review of Scientific Information on the Effects of Suspended Sediments on Pacific herring (*Clupea pallasi)* Reproductive Success. April 2005.
White Paper: Potential Impacts of Dredging on Pacific Herring in San Francisco Bay. March 2005.
Impacts of Suspended Sediments on Fertilization, Embryonic Development, and Early Larval Life Stages of the Pacific herring, *Clupea pallasi.* April 2009
Impacts of Suspended Sediments on Fertilization, Embryonic Development and Early Larval Life Stages of the Pacific Herring, *Clupea pallasi.* July 2008.

Methylmercury
Mercury Concentrations Bordering The Hamilton Army Air Field Remediation Site: September, 2001. October 2002.
Mercury Concentrations Bordering The Hamilton Army Air Field Remediation Site: February. 2003. September 2003.
Pre-Construction Biogeochemical analysis of mercury in Wetlands Bordering the Hamilton Army Airfield Wetlands Restoration Site. September 2005.
Mercury Cycle Studies Associated with the Hamilton Wetland Restoration Project. May 2006.
Pre-Construction Biogeochemical analysis of mercury in Wetlands Bordering the Hamilton Army Airfield (HAAF) Wetlands Restoration Site. Part 2. September 2007.
Pre-Construction Biogeochemical analysis of mercury in Wetlands Bordering the Hamilton Army Airfield (HAAF) Wetlands Restoration Site. Part 3. December 2009.
Comparison of DGT Sentinels and Bioassays for Long-term Mercury TMDL Monitoring under San Francisco Bay Field Conditions. December 2009.
LTMS Symposia on Methylmercury in Dredging Operations and Dredged Sediment Reuse (January 2010)
Miscellaneous
Least Tern Literature Review and Study Plan Development. February 2012.
Tools for Assessing and Monitoring Fish Behavior Caused by Dredging Activities. June 2011.
Literature Review (for studies conducted prior to 2008): Fish Behavior in Response to Dredging & Dredged Material Placement Activities. August 2009.
Supplement to the "Framework for Assessment of Potential Effects of Dredging on Sensitive fish Species in San Francisco Bay". 2013.
Effects of Short-term Water Quality Impacts Due to Dredging and Disposal on Sensitive Fish Species in San Francisco Bay. September 2008.
LTMS Science Symposium 2007, 2008 and 2010
LTMS Symposium on Green Sturgeon, Longfin Smelt and Dredging Operations in the San Francisco Bay (December 2009)
Dredging 201: The Permit Process and Beyond Workshop
Draft Reports
Juvenile Salmonid Outmigration: Interim Draft Report 2008-2009
Juvenile Salmonid Outmigration & Green Sturgeon: Distribution Draft Annual Report 2009, 2010 & 2011
Juvenile Salmonid Outmigration and Distribution in the San Francisco Estuary: Draft Annual Report. September 2007
Draft San Francisco Bay Juvenile Salmonid distribution and Tracking Project: Data Report. 14 August 2007.
Potential Impacts of Re-suspended sediments associated with Dredging and Dredged material placement of fishes in San Francisco Bay, California – Literature review and identification of Data Gaps. July 2010.
Draft - Bibliography of Scientific Literature on Pacific Herring (*Clupea pallasi)*, with Additional Selected References for Baltic Herring (*Clupea harengus)*. August 2004.

1.3 Proposed Action

The Corps and EPA propose to continue implementation of the LTMS dredging as described below with the addition of several conservation and mitigation measures described in section 1.3.4 below. This reinitiation of consultation on the LTMS Program and this biological opinion applies to operations and maintenance dredging within San Francisco, San Pablo and Suisun Bays, as well as areas immediately outside the Golden Gate at San Francisco Bar and Ocean Beach, conducted by the Corps, other federal agencies, and non-federal entities. Corps and EPA authorities for these actions are as follows.

Non-Corps dredging and disposal of dredged material in the San Francisco Bay Region requires a Department of Army permit pursuant to Section 404 of the Clean Water Act (CWA), Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA), and Section 10 of the Rivers and Harbor Act of 1899. For Corps' conducted dredging projects, the Corps does not issue itself a CWA section 404 permit, but the CWA's Section 404(b)(1) Guidelines and other substantive requirements of the CWA and other environmental laws do apply. EPA provides oversight to the Corps CWA permit program, and has additional authorities pursuant to the Marine Protection, Resources, and Sanctuaries Act (MPRSA). Section 102 of the MPRSA authorizes EPA to establish criteria for evaluating all dredged material proposed for ocean dumping. These criteria are published separately in the Ocean Dumping Regulations at 40 C.F.R. pt. 220-228. Section 102 also authorizes EPA to designate permanent ocean-dredged material disposal sites in accordance with specific site selection criteria designed to minimize the adverse effects of ocean disposal of dredged material.

Under the LTMS Program, dredging is performed at 11 federal navigation channels (Table 2 and Figure 1) and approximately 100 maintenance dredging sites associated with ports, marinas, and homeowners associations (Table 3 and Figure 1). There are seven in-water disposal locations that are currently in use: Ocean Disposal (SF-DODS); San Francisco Bar (SF-8); Carquinez Strait (SF-9); San Pablo Bay (SF-10); Alcatraz (SF-11); Suisun Bay (SF-16); and Ocean Beach Demonstration Site (SF-17) (Figure 1).

A primary goal of the LTMS Program is to reduce the amount of in-Bay disposal. Specifically, the plan aims for a minimum of 40 percent of all dredged material to be beneficially reused (e.g., for enhancing or creating aquatic habitat, maintaining levees, etc.), up to 40 percent of material to be discharged offshore at the EPA-designated San Francisco Deep Ocean Disposal Site (SF-DODS) when beneficial reuse is not feasible, and no more than 20 percent of dredged material to be discharged in Bay (referred to as the "40-40-20 Plan"). The long-term goal of the LTMS Program is to limit in-bay disposal volumes to a maximum of 1.25 million cubic yards per Year (plus 250,000 cubic yards contingency).

Figure 1. LTMS Dredging and Disposal Locations

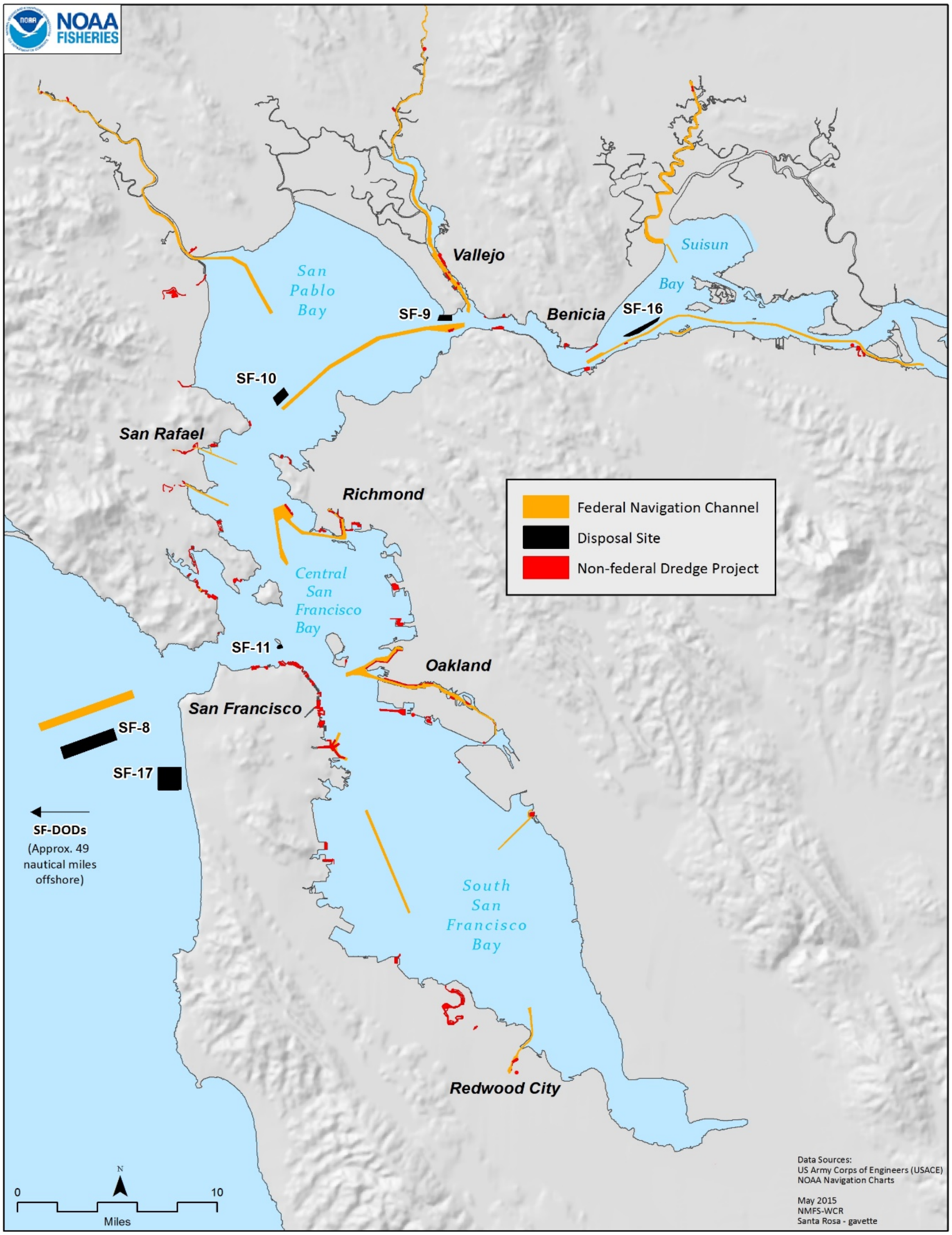

Table 2. Corps Dredging of Federal Navigation Channels in SF Bay Region 2000-2014
Source: Federal Navigation Channels draft EA/EIR, December 2014.

Channel	Dredge Type	Typical Dredging Frequency (years)	Range of Volume Dredged per Episode (CY)[1]	Median Volume Dredged Per Episode (CY)[2]	Placement Site
Richmond – Inner Harbor	Clamshell-Bucket	1	11,000 – 631,000	390,000	SF-DODS, Upland24,870
Outer Harbor	Hopper	1	78,000 – 318,000	190,000	SF-11
San Francisco Harbor – Main Ship Channel	Hopper	1	78,000 – 613,000	306,000	SF-8, SF-17
Napa River Channel*	Cutterhead-Pipeline	6-10	140,000[3]	140,000[3]	Upland (Sponsor Provided)
Petaluma River Channel (and Across the Flats*)	Cutterhead-Pipeline (River Channel) Clamshell-Bucket (Across the Flats)	4-7	150,000[3]	150,000[3]	Upland (Sponsor Provided) for the River Channel SF-10 for Across the Flats
San Rafael Creek Channel	Clamshell-Bucket	4-7	78,000 – 87,000[3]	83,000[3]	SF-11
Pinole Shoal	Hopper	1	80,000 – 487,000	146,000	SF-10
Suisun Bay Channel and New York Slough	Hopper	1	21,000 – 423,000	159,000	SF-16
Oakland Inner and Outer Harbor	Clamshell-Bucket	1	122,000 – 1,055,000[4]	330,000	SF-DODS, MWRP
San Leandro Marina (Jack D. Maltester Channel)	Cutterhead-Pipeline	4-6	121,000 – 187,000[3]	154,000[3]	Upland (Sponsor Provided)
Redwood City Harbor	Clamshell-Bucket (Harbor Channels) Hopper (San Bruno Channel)	1-2	10,000 – 560,000	179,000	SF-11

Notes:
* For areas not dredged since 2000, the last dredging event is reported.
1 Range of volume dredged per fiscal year since 2000 (USACE, 2014). For areas not dredged since 2000, the last dredging event is reported.
2 Median volume dredged per fiscal year since 2000. For areas not dredged since 2000, the last dredging event is reported.
3 Due to the lower frequency at which these channels are dredged, future dredge volumes could be greater.
4 Due to the deepening of Oakland Harbor completed in 2010, future dredge volumes could be greater.
CY = cubic yards, MWRP = Montezuma Wetlands Restoration Project, Solano County

Table 3. San Francisco Bay Region non-Corps dredge project sites. Latitudes and longitudes are provided for reference only and do not represent spatial extent of sites.

Name	Latitude	Longitude
Aeolian Yacht Club	37° 45.003' N	122° 14.079' W
Alameda Point Channel	37° 46.441' N	122° 18.907' W
Arques Shipyard and Marina	37° 52.064' N	122° 29.769' W
Ballena Isla Marina	37° 45.978' N	122° 17.109' W
Ballena Isla Townhomes	37° 46.149' N	122° 17.240' W
Bel Marin Keys Community Services District	38° 5.686' N	122° 29.445' W
Bellevue Channel (Belvedere Cove)	37° 52.337' N	122° 27.575' W
Belvedere Land Company	37° 52.363' N	122° 27.584' W
Benicia Marina	38° 2.597' N	122° 9.444' W
Benicia Port Terminal (Amport)	38° 2.488' N	122° 8.087' W
Berkeley Marina	37° 52.122' N	122° 18.972' W
Black Point Boat Launch Ramp	38° 6.880' N	122° 30.356' W
BP, Richmond Terminal	37° 54.439' N	122° 21.817' W
Brickyard Cove Homeowners Association	37° 54.497' N	122° 22.799' W
Brisbane Marina at Sierra Point	37° 40.462' N	122° 22.797' W
C&H Sugar Company	38° 3.494' N	122° 13.083' W
CA Maritime Academy	38° 3.976' N	122° 13.835' W
Cass Marina Turney Boat Ramp	37° 51.615'N	122° 29.116'W
Castrol North American Consumer's Berth	37° 55.342' N	122° 22.367' W
Chevron Rod and Gun	37° 57.617' N	122° 24.658' W
Chevron, Richmond Long Wharf	37° 55.492' N	122° 24.766' W
City of Emeryville Marina	37° 50.430' N	122° 18.750' W
City of Napa, JFK Boat Ramp	38°15.929'N	122°17'.04'W
City of Suisun Pierce Island Boat Ramp	38° 13.980' N	122° 2.249' W
City of Sunnydale Boat Ramp	37° 26.131' N	122° 1.622' W
Clipper Yacht Harbor	37° 51.858' N	122° 29.543' W
Coast Guard Station, Golden Gate	37° 49.968' N	122° 28.633' W
Coast Guard Station, Yerba Buena Island	37° 48.685' N	122° 21.637' W
Coast Guard, Alameda Station	37° 46.780' N	122° 14.963' W
Conoco Philips, Richmond	37° 54.754' N	122° 21.875' W
Conoco Philips, Rodeo Terminal	38° 3.421' N	122° 15.711' W
Corinthian Yacht Club	37° 52.359' N	122° 27.406' W
Corona Del Mar Homeowners Association	37° 45.832' N	122° 13.513' W
Coyote Point Marina	37° 35.339' N	122° 19.012' W
Emery Access Chanel	37° 50.563' N	122° 18.867' W
Emery Cove Marina	37° 50.312' N	122° 18.628' W
Exploratorium	37° 48.160' N	122° 23.902' W
Foster City Lagoon	37° 32.647' N	122° 15.829' W
Galilee Harbor	37° 51.759' N	122° 29.329' W
Gallinas Creek	38° 1.023' N	122° 30.472' W
Glen Cove Marina	38° 4.023' N	122° 12.790' W
Greenbrae Marina Neighborhood	37° 56.540' N	122° 30.627' W
Hanson Aggregates	37° 45.799' N	122° 13.439' W
Harbor Bay Ferry Channel	37° 44.143' N	122° 15.479' W
High Tide Boat Sales	37° 58.080' N	122° 30.718' W
Jackson Property	37° 45.862' N	122° 13.526' W

Johnson Property	37° 52.405' N	122° 27.644' W
Kappas Marina – Richardson Bay Marina	37° 52.580' N	122° 30.262' W
Kiewit Pacific Company	38° 5.477' N	122° 15.294' W
Larkspur Landing Ferry Terminal	37° 56.744' N	122° 30.551' W
Larkspur Marina	37° 56.417' N	122° 31.391' W
Larkspur Sea Scout Base	37° 56.587' N	122° 30.699' W
Levin-Richmond Terminal Corporation	37° 55.269' N	122° 22.017' W
Loch Lomond Marina – Marina Village	37° 58.343' N	122° 28.867' W
Lowrie Yacht Harbor	37° 58.037' N	122° 30.469' W
Mare Island Shipyard	38° 5.796' N	122° 15.869' W
Marin Rowing Association	37° 56.557' N	122° 31.026' W
Marin Yacht Club	37° 58.315' N	122° 29.922' W
Marina Bay Yacht Harbor	37° 54.804' N	122° 20.960' W
Marina Plaza Harbor	37° 52.008' N	122° 29.706' W
Marina Vista Canal and Homeowners Assoc.	37° 58.385' N	122° 29.754' W
Martinez Marina	38° 1.629' N	122° 8.230' W
Martinez Shore Terminal	38° 2.748' N	122° 6.082' W
Montezuma Harbor	38° 11.229' N	121° 58.230' W
Napa Valley Marina	38° 13.245' N	122° 18.783' W
Oakland Yacht Club	37° 47.021' N	122° 15.818' W
Oyster Cove Marina	37° 39.821' N	122° 22.709' W
Oyster Point Marina	37° 39.820' N	122° 22.682' W
Paradise Cay Homeowners Assoc.	37° 54.825' N	122° 28.659' W
Paradise Cay Yacht Club	37° 54.930' N	122° 28.590' W
Petaluma Marina	38° 13.797' N	122° 36.811' W
Petaluma River Turning Basin	38° 14.106' N	122° 38.262' W
Pittsburg Marina	38° 2.143' N	121° 52.950' W
Plains Marketing (Martinez Shore Terminal)	38° 2.612' N	122° 6.142' W
Point San Pablo Yacht Club	37° 57.818' N	122° 25.103' W
Port of Oakland	37° 48.646' N	122° 19.715' W
Port of Redwood City	37° 30.808' N	122° 12.576' W
Port of Richmond	37° 54.729' N	122° 21.876' W
Port of San Francisco	37° 48.022' N	122° 23.770' W
Port Sonoma Marina	38° 7.060' N	122° 29.949' W
Redwood City Marina	37° 30.421' N	122° 12.727' W
Redwood City Harbor	37° 30.292' N	122° 12.420' W
Redwood Shores Lagoon	37° 32.315' N	122° 14.691' W
Richmond Yacht Club	37° 54.510' N	122° 23.015' W
RMC Lonestar Cement Marina Terminal	37° 30.850' N	122° 12.522' W
Ron Valantine Boat Dock	37° 46.160' N	122° 17.255' W
Ryer Island Boat Harbor (Veneco)	38° 4.467' N	122° 0.713' W
San Francisco Dry Dock	37° 45.801' N	122° 22.984' W
San Francisco Marina (Golden Gate & St. Francis Yacht Clubs)	37° 48.410' N	122° 26.661' W
San Francisco Yacht Club	37° 52.308' N	122° 27.735' W
San Leandro Marina	37° 41.820' N	122° 11.485' W
San Rafael Creek, Residential Berths (Canal)	37° 58.068' N	122° 30.680' W
San Rafael Rock Quarry	37° 59.302' N	122° 26.838' W
San Rafael Yacht Harbor	37° 58.134' N	122° 31.062' W
Sausalito Marina Properties	37° 51.603' N	122° 29.044' W
Sausalito Yacht Club/Harbor	37° 51.581' N	122° 28.877' W

Schnitzer Steel	37° 47.628' N	122° 17.538' W
Schoonmaker Point Marina	37° 51.859' N	122° 29.479' W
Shamrock Materials	38° 13.515' N	122° 36.478' W
Shell Terminal	38° 2.002' N	122° 7.380' W
South Beach Yacht club	37° 46.804' N	122° 23.158' W
Strawberry Recreation District	37° 53.311' N	122° 30.001' W
Suisun City Marina	38° 14.056' N	122° 2.247' W
Time Oil Terminal	37° 55.079' N	122° 21.856' W
Timmers Landing	37° 54.554' N	122° 28.481' W
Tosco Refinery	37° 54.926' N	122° 21.900' W
US Army Reserve Center, Mare Island	38° 5.277' N	122° 15.468' W
USCG Integrated Support Command, Alameda	37° 46.753' N	122° 14.943' W
USCG Station Golden Gate	37° 49.996' N	122° 28.581' W
USCG Station Vallejo/Mare Island	38° 6.751’ N	122° 16.265’ W
USCG Station Yerba Buena Island	37° 48.568' N	122° 21.677' W
USS Posco	38° 1.915' N	121° 52.250' W
Valero Refinery Co. - Benicia Crude Dock	38° 2.676' N	122° 7.741' W
Vallejo Ferry Terminal	38° 5.982' N	122° 15.808' W
Vallejo Marina	38° 6.424' N	122° 16.096' W
Vallejo Yacht Club	38° 6.283' N	122° 16.063' W
WesPac Energy Pittsburg	38° 2.542’ N	121°53.565’ W
WETA Central Bay Ferry Maintenance Facility	37°46'16.48"N	122°17'57.29"W
WETA Harbor Bay Terminal	37°44.182’ N	122°15.423’ W
WETA Vallejo Baylink Ferry Terminal	38° 6.001' N	122° 15.789' W

Program administration and activities are described in detail below, with certain limitations and restrictions. Specifically, this programmatic consultation will not cover the following: (1) any new or previously unauthorized dredging; (2) any deepening of areas below currently authorized depths plus allowable overdepth; (3) dredging for power plant maintenance; and (4) dredging for levee maintenance. The reinitiated consultation and this biological opinion consider the effects of the remaining duration of the LTMS Program. Originally a 50-year program, the LTMS has been in effect for 15 years, resulting in a 35-year remaining lifetime for the program.

No interrelated and interdependent activities have been identified for this project. Although the proposed LTMS Program will help maintain existing maritime facilities including marinas, docks, wharfs, ports and navigation channels, future implementation of the program will not increase in the number of vessel transits per day, vessel size, or other maritime activities in the action area for the foreseeable future because the LTMS Program does not include any additional dredging for new or expanded maritime facilities. Therefore, the impacts of shipping and other maritime activities are considered as part of the environmental baseline.

1.3.1 Administration of the Program

The DMMO will continue to provide a coordinated review of dredging and dredged material disposal project proposals[1]. The DMMO does not issue permits; rather it makes consensus-based recommendations to the member agencies on the completeness of permit applications, adequacy of sediment sampling and analysis plans (SAP), and suitability of sediments for proposed disposal locations.

The DMMO meets twice monthly to exchange technical information about dredging projects. Meetings are open to the public. The Corps serves as the "host" agency for the DMMO and provides logistical support for meetings. The Corps also maintains DMMO files and maintains the DMMO website, containing information on the DMMO and dredging-related issues. Dredge permit applicants must submit to the DMMO a SAP to confirm the suitability of sediment proposed to be dredged for unconfined aquatic placement in-Bay or at San Francisco Deep Ocean Disposal Site (SF-DODS), or upland/beneficial reuse placement. However, an applicant may alternatively submit a written request for a "Tier I" exclusion from the testing requirements based on factors such as previous testing history and physical characteristics of the material proposed for dredging. The LTMS Program permitting agencies (i.e., Regional Water Board, EPA, Corps, and BCDC) have delegated to the DMMO ultimate discretion over the required content and adequacy of the SAP. Sediment testing and analysis must be implemented as approved in the SAP and the results presented to the DMMO. Based on the results of sediment testing, the DMMO is responsible for ensuring all material dredged is physically, chemically, and biologically suitable for its disposal/placement site.

When some material is not suitable for the proposed disposal or placement site, the DMMO works with permittees to identify an appropriate alternative placement or disposal site. In cases where an alternative site is unavailable or perceived as too costly to use, permittees often choose not to immediately dredge that portion of the project. In addition to addressing sediment quality, the DMMO works closely with permittees to ensure dredging and disposal is performed within the relevant environmental work windows and other permit requirements. Annual reports prepared by the DMMO summarize the dredging and disposal activities of the previous year, and this information is used by the LTMS agencies for periodic review of the program.

In response to Conservation Measures developed during the 2011 NMFS-Corps consultation pursuant to the essential fish habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the DMMO improved its procedures and requirements for sediment testing at dredge projects conducted in San Francisco Bay. Specifically, the new procedures include more systematic and predictable requirements for bioaccumulation testing and "residual" (post-dredge sediment surface) sampling and characterization. The program improvements also tie the sediment testing to San Francisco

[1] The DMMO is a joint program with representation from the Corps, EPA, BCDC, and Regional Water Board, and State Lands Commission. NMFS, California Department of Fish and Wildlife, and U.S. Fish and Wildlife Service are encouraged to participate at DMMO meetings as commenting resource agencies (see consultation history section of this opinion).

Bay's existing Total Maximum Daily Load (TMDL) for mercury and PCB's, and the Regional Monitoring Program for San Francisco Bay. The Regional Monitoring Program is part of a region-wide program aimed at identifying chemical thresholds for sediment management. The LTMS agencies consider the DMMO and the sediment testing requirements to be ongoing projects that will continue to adapt as scientific understanding improves, testing methods advance, and resources permit.

1.3.2. Dredging Activities

Dredging involves the removal or excavation of bottom sediments from the aquatic environment in order to create or maintain waterways deep enough to support navigation, including access channels, turning basins, ports, and marinas. Dredging methods can be divided into two broad categories, mechanical and hydraulic (Gren 1976), differentiated primarily by the volume of water furnished with the dredged material. Mechanical dredges are commonly used for smaller, localized sites, and include clamshell, bucket, and excavator dredges. Hydraulic dredges remove and transport sediments by suction and pumping, which mixes large volumes of water with the sediment to form a slurry that is piped or barged to a disposal area. The most common hydraulic dredges include the cutterhead and the hopper dredge. Below is a list of the actions currently employed for the purpose of maintaining previously dredged areas in the San Francisco Bay Region.

1.3.2.1 Mechanical Dredging

Mechanical dredges remove bottom sediments by direct application of mechanical force to dislodge sediments, scooping the sediments from the bottom and placing them into a barge or scow for transport to a dredge disposal or reuse site. Mechanical dredging is typically used at the larger port and wharf facilities. Buckets on mechanical dredges typically range in size from 1 to 25 cubic yards.

Clamshell: A clamshell dredge employs a vertical loading grabber connected to wire rope which is lowered in the open position into the sediment, closed around the sediment load, and raised above the water surface where the sediment is deposited on a barge. Several diverse bucket configurations are available to be specifically tailored to the various sediment types.

Environmental bucket: An environmental bucket is similar to a conventional clamshell dredge; however the environmental bucket generally has features that include some combination of covers, exterior pulleys, and sealed joints, intended to reduce the amount of sediments that can spill or flow out of the bucket during dredging activities (Wang *et al*. 2002).

Excavator: Excavator dredging involves a backhoe excavator mounted to a barge. The excavator bucket is lowered to the seafloor where it scoops up sediment, brings the sediment up through the water column in the open bucket, where it is deposited on the barge.

1.3.2.2 Hydraulic Dredging

Hydraulic dredges remove bottom sediments by suction force and those sediments are transported in the liquid slurry form for storage or transport to a disposal site. The Corps frequently operates one of two government-owned hopper dredges *Essayons* and the *Yaquina*, in San Francisco Bay for maintenance of Federal navigation channels. Small scale suction dredge are commonly used for marina projects and under-pier clearing. The intakes of some hydraulic dredges are equipped with a rotating cutter apparatus (i.e., cutterhead) to help break up bottom sediments and facilitate the pumping of the sediment up through the pipe.

Suction/Hopper: Hopper dredges are ships with both a suction pipe for dredging and a large hull for holding and transporting the dredged material. Hopper dredges are equipped with a drag arm, long suction pipes with drag heads attached to the end. During active dredging, the drag arm is slowly dragged across the seafloor using the forward motion of the vessel. The sediment and water slurry is drawn up through the drag head and drag arm by on-board pumps and deposited within the hopper bin. Once full, dredging ceases and hopper dredges move directly to the disposal site where dredged material is disposed through large doors at the bottom of the dredge. Although the *Essayons* and the *Yaquina* are not currently equipped as such, some hopper dredges have the ability to offload material via pipeline and pumps directly to an upland or beneficial reuse site. The intake pipe on the *Essayons* is 28 inches in diameter and the intake pipe on the *Yaquina* is 20 inches.

Suction: Suction dredges without a "hopper" cannot store the dredged material on-board and typically transport dredged materials in a slurry via pipeline for disposal at an upland or beneficial reuse location. As with hopper dredges, suction dredges are equipped with a drag arm and this arm moves across the seafloor to collect sediments. The most common small barge-mounted suction dredge used in San Francisco Bay is equipped with an 8- to 12-inch diameter intake.

1.3.2.3 Knockdown

Knockdowns employ an I-beam or other similar equipment to redistribute shoaled sediment into deeper areas within the dredging site. These are generally used for smoothing the bottom following conventional mechanical or hydraulic dredging, and for managing localized mounds without the need to mobilize a full dredging episode. Typically knockdowns are used to alleviate shoaling in marinas, ports, and in some navigational channels.

1.3.3 Disposal

During the dredging process the sediment removed from the seafloor must be transported to and disposed of at an alternate location. Dredged material may be deposited in several different location types, including in-bay, nearshore and offshore locations, and upland disposal locations.

1.3.3.1 In-Bay Aquatic Disposal

In-bay disposal sites are open water locations within the estuarine waters of San Francisco Bay and inside the Golden Gate. There are currently four in-bay sites approved for disposal: Carquinez Strait (SF-9); San Pablo Bay (SF-10); Alcatraz (SF-11); and Suisun Bay (SF-16) (Figure 1).

1.3.3.2 Nearshore Aquatic Disposal

Nearshore disposal sites are open water locations in ocean waters outside the Golden Gate, but within 10 nautical miles of the Golden Gate Bridge. Currently there are two nearshore sites designated for placement of dredged material: San Francisco Bar Channel (SF-8) and Ocean Beach Demonstration Site (SF-17), both located south of the Main Ship Channel (Figure 1).

1.3.3.3 Ocean Disposal

Offshore disposal sites are deep open water locations in ocean waters outside of the Golden Gate Bridge. There is currently only one offshore disposal site. The San Francisco Deep Ocean Disposal Site (SF-DODS) is located approximately 49 nautical miles outside the Golden Gate (Figure 1).

1.3.3.4 Upland Disposal/Beneficial Reuse

Upland disposal includes any disposal site not located in the open waters of the San Francisco Bay estuary or ocean waters. Upland disposal may include a sanitary landfill or a beneficial reuse site. Beneficial use is the use of dredged material for human or environmental purposes and are intended to provide benefits beyond that of simple disposal. Beneficial reuse sites include placement at diked former bayland areas under conversion to wetlands, shoreline stabilization and erosion control, levees requiring maintenance, beach nourishment, construction sites, or capping of contaminated sediments. Both mechanical and hydraulic equipment may be used to transport dredged material to an upland disposal or beneficial reuse site.

Beneficial reuse sites for dredged material utilized by the LTMS Program to date include Montezuma Wetlands, Port of Oakland Middle Harbor Enhancement Area, Inner Bair Island, Hamilton Wetland Restoration Site, Sonoma Baylands, Winter Island and several remediation project sites. Upland/beneficial reuse sites are typically confined disposal in diked nearshore areas so that dredged materials do not come in direct contact with aquatic environs. Beneficial reuse sites currently available in 2015 to accept dredged material are limited to Montezuma Wetlands, Winter Island, and Cullinan Ranch; however, several additional sites are anticipated to be developed over the remaining term of the LTMS Program.

1.3.4 Avoidance, Minimization and Mitigation Measures

The October 2014 LTMS Program consultation update provided to NMFS by the Corps and EPA proposes the following measures to avoid, minimize and mitigate the impacts of dredging and disposal in the San Francisco Bay Region. Corps conducted or funded dredging of federal navigation channels will be performed in compliance with these measures. Non-federal dredge projects authorized by the Corps' Regulatory Branch will include these measures as permit conditions.

1.3.4.1 Environmental Work Windows

1. For NMFS-listed salmon, steelhead and green sturgeon in San Francisco Bay (inshore of the Point Lobos-Point Bonita line), San Pablo Bay, and Suisun Bay, the work window is June 1 through November 30. Routine dredging and disposal operations conducted pursuant to the LTMS program during this time frame do not need further coordination with NMFS.

2. No dredging (mechanical or hydraulic) will be permitted from December 1 through May 31 upstream or within 1000 feet bayward of the mouths of Larkspur/Corte Madera Creek, Napa River Channel/Mare Island Strait (including Vallejo), Petaluma River, and Novato Creek without individual consultation.

3. For all other locations, a proponent may plan a project that performs work outside the work window (e.g., from December 1 through May 31) if the project mitigates for potential impacts by placing the dredged sediment at a beneficial reuse site that NMFS agrees will provide aquatic habitat benefits, such as tidal wetlands restoration. (For the purposes of this consultation only the portion of the material that is dredged between December 1 and May 31 is required to be placed at the beneficial reuse site.) If a project is unable to place all of the material dredged outside the work window at a beneficial reuse site (e.g., due to equipment constraints or site availability), absent additional consultation, the project proponent will be required to provide an equivalent volume of material, deemed suitable for the purpose by DMMO, to a similar beneficial reuse site from a dredging project conducted inside the work window (June 1 to November 30) and not otherwise planned to go to a reuse site benefitting aquatic habitat. (The intent is to mitigate for the additional potential impacts of dredging outside the window by providing more aquatic habitat benefit than would otherwise have occurred under an applicable, approved Alternatives Analysis.) The placement of a like volume of dredged material at a beneficial reuse site must occur within 12 months of the end of the previous work window (i.e. November 30th).

4. For projects with unplanned and unavoidable needs to complete a portion of their ongoing dredging outside of the work window (e.g. due to weather delays or mechanical breakdown), the LTMS agencies at their discretion may approve up to a cumulative total of 50,000 cubic yards per year of dredging outside the work window without further

coordination with NMFS and without the need for further mitigation. For the purposes of this consultation, these small volumes may continue to be placed at the site(s) otherwise approved for the project(s) during the work window.

1.3.4.2 Best Practices for All Dredgers Regardless of Equipment Type (as applicable)

1. Minimize Dredging and Disposal
    a. Dredging at each project location will continue to be limited to the approved project depth plus over-depth.
    b. Knockdowns and advance maintenance proposed to reduce dredging and disposal volume or to extend the time needed between full dredging episodes may be approved by DMMO as appropriate.
2. Minimize Impacts of Dredging
    a. No overflow or decant water will be allowed to be discharged from any barge, with the exception of spillage incidental to clamshell dredge operations, unless monitoring or relevant studies show the effects of such discharge are negligible on water quality.
    b. To reduce turbidity that may affect fish habitat, return water overflow from hopper-type suction dredges would continue to be limited to no longer than 15 minutes at the dredge site during any one excavation action (cut). Overflow would be unrestricted when dredged material is greater than 90 percent sand.
    c. Turbidity control and/or monitoring measures will be required per the provisions of the LTMS Programmatic EFH Agreement when dredging occurs in proximity to identified eelgrass zones.
    d. Mitigation for any direct loss of eelgrass due to dredging will occur in consultation with NMFS, per the provisions of the LTMS Programmatic EFH Agreement.
3. Minimize Impacts of Disposal
    a. Monthly and annual disposal volume limits will remain in place for each in-Bay disposal site.
    b. The overall (average annual) in-Bay disposal volume limit set forth in the LTMS Management Plan will continue to be managed by DMMO.
    c. Where applicable, projects must be conducted in accordance with an Alternatives Analyses or Integrated Alternatives Analysis approved by the LTMS agencies, to demonstrate that they are meeting the LTMS in-Bay disposal goals to the extent practicable and feasible.

1.3.4.3 Additional Best Practices for Hydraulic Dredging

1. For hopper or pipeline dredging projects, a worker education program will be implemented for listed fish that could be adversely impacted by dredging. The program will include a presentation to all workers on biology, general behavior, distribution, habitat needs, sensitivity to human activities, legal protection status, and

project-specific protective measures for each listed species. Workers would also be provided with written materials containing this information.

2. Draghead or pipeline pumps will only be turned on when the dragheads, cutterheads, or pipeline intakes are on the seafloor or within 3 feet of the seafloor when priming pumps.
3. Draghead, cutterheads, or pipeline intakes will be monitored so that they maintain positive contact with the seafloor during suction dredging.
4. Hopper dredges will close, to the extent possible, the draghead water intake port's doors in locations most vulnerable to entraining or entrapping listed fish. Typically, the drag arms do not clog when dredging areas are composed mostly of sand. However, in circumstances when the draghead intake port's doors need to be opened to alleviate clogging, the doors would be opened incrementally (i.e., one at a time until the clog is removed) to ensure that doors are not fully opened unnecessarily. It may take multiple iterations to fine tune the exact intake door opening necessary to prevent clogging. For each project the intake door opening will be different because the sediment in each project is different and the sediment physical characteristics (sand vs. mud) determine how much water is needed to slurry the sediment adequately.

1.4 Action Area

The action area is defined as all areas affected directly or indirectly by the Federal action and not merely the immediate area involved (50 CFR 402.02). The action area for the proposed LTMS Program encompasses all areas that will be affected by dredging and disposal activities as well as implementation of conservation and mitigation actions. The action area includes the water column and substrate within 11 federal navigation channels, and approximately 100 dredging sites at ports, marinas, and homeowners associations in South San Francisco Bay, Central San Francisco Bay, San Pablo Bay and Suisun Bay plus the water column down current of a dredging equipment to include the turbidity plume created by excavation and or overflow of water from the barge (Figure 1). The action area also includes four in-bay disposal sites and three disposal sites outside the Golden Gate. The four in-bay disposal sites are Carquinez Strait (SF-9), San Pablo Bay (SF-10), Alcatraz (SF-11), and Suisun Bay (SF-16) (Figure 1). The three disposal sites outside the Golden Gate are SF-DODS, the San Francisco Bar Channel Disposal Site (SF-8) and Ocean Beach (SF-17) (Figure 1).

2.0 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

2.1 Analytical Framework

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 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 C.F.R. 402.02, which was invalidated by *Gifford Pinchot Task Force v. USFWS*, 378 F.3d 1059 (9th Cir. 2004), amended by 387 F.3d 968 (9th Cir. 2004). Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

2.1.1 Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this biological opinion has four components: (1) the Status of the Species, which evaluates the range-wide conditions, the factors responsible for that condition, and the species' likelihood of both survival and recovery for CCC steelhead DPS, CCV steelhead DPS, Central Valley spring-run Chinook salmon evolutionarily significant unit (ESU), Sacramento River winter-run Chinook salmon ESU, and southern DPS of North American green sturgeon; (2) the Environmental Baseline, which evaluates the condition of these listed species in the action area, the factors responsible for that condition, and the relationship of the action area to the likelihood of both survival and recovery of these listed species; (3) the Effects of the Action, which determines the direct and indirect effects of the proposed Federal action and the effects of any interrelated or interdependent activities on these species in the action area; and (4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on these species.

The jeopardy determination is made by adding the effects of the proposed Federal action and any Cumulative Effects to the Environmental Baseline and then determining if the resulting changes in species status in the action area are likely to cause an appreciable reduction in the likelihood of both the survival and recovery of this listed species in the wild.

The jeopardy analysis in this biological opinion places an emphasis on the range-wide likelihood of both survival and recovery of this listed species and the role of the action area in the survival and recovery of these listed species. The significance of the effects of the proposed Federal action is considered in this context, taken together with cumulative effects, for purposes of making the jeopardy determination. We use a hierarchical approach that focuses first on whether or not the effects on listed fish in the action area will impact their respective population. If the population will be impacted, we assess whether this impact is likely to affect the ability of the population to support the survival and recovery of the DPS or ESU.

2.1.2 Adverse Modification Analysis

The adverse modification analysis in this biological opinion relies on four components: (1) the Status of Critical Habitat, which evaluates the range-wide and watershed-wide condition of critical habitat for the CCC steelhead DPS, Sacramento River winter-run Chinook salmon ESU, and southern DPS of North American green sturgeon in terms of primary constituent elements (PCEs – sites for spawning, rearing, and migration) or physical and biological features, the factors responsible for that condition, and the resulting conservation value of the critical habitat overall; (2) the Environmental Baseline, which evaluates the condition of critical habitat in the action area, the factors responsible for that condition, and the conservation value of critical habitat in the action area; (3) the Effects of the Action, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and physical and biological features in the action area and how that will influence the conservation value of affected critical habitat units; and (4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and physical and biological features, and how that will influence the conservation value of affected critical habitat units.

For purposes of the adverse modification determination, we add the effects of the proposed Federal action on CCC steelhead, Sacramento River winter-run Chinook salmon, and North American green sturgeon critical habitat in the action area, and any Cumulative Effects, to the Environmental Baseline and then determine if the resulting changes to the conservation value of critical habitat in the action area are likely to cause an appreciable reduction in the conservation value of critical habitat range-wide. If the proposed action will negatively affect PCEs or physical and biological features of critical habitat in the action area, we then assess whether or not this reduction will impact the value of the DPS or ESU critical habitat designation as a whole.

2.1.3 Use of Best Available Scientific and Commercial Information

To conduct the assessment, NMFS examined an extensive amount of information from a variety of sources. Detailed background information on the biology and status of the listed species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, and governmental and non-governmental reports. Additional information regarding the effects of the proposed dredging and disposal actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was formulated from the aforementioned resources, and the following:

(1) LTMS Final Policy Environmental Impact Statement/Programmatic Environmental Impacts Report. Prepared by U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, December 1998.

(2) LTMS for the Placement of Dredged Material in the San Francisco Bay Region, Management Plan 2001. Prepared by U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, July 2001.

(3) LTMS Six Year Program Review. Prepared by U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board. May 1, 2006.

(4) LTMS 12-Year Review Final Report. Prepared by U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board. August 2013

(5) Draft Environmental Assessment/Environmental Impact Report, Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay, Fiscal Years 2015-2024. Prepared for: U.S. Army Corps of Engineers and San Francisco Bay Regional Water Quality Control Board; Prepared by URS Group, Inc. December 2014.

Information was also provided in emails messages and telephone conversations between November 2006 and April 2015. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document. A complete administrative record of this consultation is on file at the NMFS North-Central Coast Office (Administrative Record Number 151422SWR2014SR000251).

2.2 Status of the Species and Critical Habitat

This biological opinion analyzes the effects of the proposed San Francisco Bay, San Pablo Bay and Suisun Bay dredging projects on the following Federally-listed species (DPS or ESU) and designated critical habitats:

Central California Coast steelhead (*Oncorhynchus mykiss*) DPS
Threatened (71 FR 834; January 5, 2006)
Critical habitat (70 FR 52488; September 2, 2005)
California Central Valley steelhead (*O. mykiss*) DPS
Threatened (71 FR 834; January 5, 2006)
Central Valley Spring-run Chinook salmon (*O. tshawytscha*) ESU
Threatened (70 FR 37160; June 28, 2005)
Sacramento River Winter-run Chinook salmon (*O. tshawytscha*) ESU
Endangered (70 FR 37160; June 28, 2005;)

Critical habitat (58 FR 33212; June 16, 1993)

North American Green Sturgeon (*Acipenser medirostris*) southern DPS

Threatened (71 FR 17757; April 7, 2006)

Critical habitat (74 FR 52300; September 8, 2008)

Critical habitat for CCV steelhead and CV spring-run Chinook salmon is not present in the action area.

CCC coho salmon was included in the 1998 NMFS biological opinion for the LTMS Program, but current information indicates this species has been extirpated from San Francisco Bay and its tributary streams. Based on the NMFS review of the updated LTMS Program, the proposed action is expected to have no effect on CCC coho salmon or its designated critical habitat.

2.2.1 Species Description, Life History, and Status

In this opinion, NMFS assesses four population viability parameters to help us understand the status of CCC steelhead, CCV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and southern DPS green sturgeon and their populations' ability to survive and recover. These population viability parameters are: abundance, population growth rate, spatial structure, and diversity (McElhany *et al*. 2000). NMFS has used existing information to determine the general condition of each population and factors responsible for the current status of each DPS or ESU.

We use these population viability parameters as surrogates for numbers, reproduction, and distribution, the criteria found within the regulatory definition of jeopardy (50 CFR 402.02). For example, the first three parameters are used as surrogates for numbers, reproduction, and distribution. We relate the fourth parameter, diversity, to all three regulatory criteria. Numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained. This results in reduced population resilience to environmental variation at local or landscape-level scales.

2.2.1.1. CCV and CCC Steelhead General Life History

Steelhead are anadromous forms of *O. mykiss*, spending some time in both freshwater and saltwater. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al*. 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Steelhead young usually rear in freshwater for 1 to 3 years before migrating to the ocean as smolts, but rearing periods of up to 7 years have been reported. Migration to the ocean usually occurs in the spring. Steelhead may remain in the ocean for 1 to 5 years (2 to 3 years is most common) before returning to their natal streams to spawn (Busby *et al.* 1996). The distribution of steelhead in the ocean is not well known. Interannual variations in climate, abundance of key prey items (e.g. squid), and density dependent interactions with other salmonid species are key drivers of steelhead distribution and productivity in the marine environment (Atcheson *et al*. 2013; Atcheson *et al*. 2012). Recent information indicates that steelhead originating from central California use a cool, stable, thermal habitat window (ranging between 8-14 degrees Celcius [°C]) in the marine environment characteristic of conditions in northern waters above the 40th parallel to the southern boundary of the Bering Sea (Hayes *et al*. 2012). Adult steelhead typically migrate from the ocean to freshwater between December and April, peaking in January and February (Fukushima and Lesh 1998).

Juvenile steelhead migrate as smolts to the ocean from January through May, with peak migration occurring in April and May (Fukushima and Lesh 1998). Barnhart (1986) reports steelhead smolts in California typically range in size from 140 to 210 millimeter (mm) (fork length). Steelhead of this size can withstand higher salinities than smaller fish (McCormick 1994), and are more likely to occur for longer periods in tidally influenced estuaries, such as San Francisco Bay. Steelhead smolts in most river systems must pass through estuaries prior to seawater entry.

2.2.1.2 Status of CCC Steelhead DPS and Critical Habitat

Historically, approximately 70 populations[2] of steelhead existed in the CCC steelhead DPS (Spence *et al*. 2008; Spence *et al*. 2012). Many of these populations (about 37) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts (Bjorkstedt *et al*. 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their viability (Bjorkstedt *et al*. 2005; McElhany *et al*. 2000).

While historical and present data on abundance are limited, CCC steelhead numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this DPS in the mid-1960s, including 50,000 fish in the Russian River - the largest population within the DPS (Busby *et al.* 1996). Near the end of the 20th century the population of wild CCC steelhead was estimated to be between 1,700- 7,000 fish (McEwan 2001). Recent estimates for the Russian River population are unavailable since monitoring data is limited. Abundance estimates for smaller coastal streams in the DPS indicate low population levels that are slowly declining, with recent estimates (2011/2012) for several streams (Redwood [Marin County], Waddell, San Vicente, Soquel, and Aptos creeks) of individual run sizes of 50 fish or less (The Nature Conservancy 2013). Some loss of genetic diversity has been documented and attributed to previous among-basin transfers of stock and local hatchery production in interior populations in the Russian River (Bjorkstedt *et al.* 2005). Similar losses in genetic diversity in the Napa River may have resulted from out-of-basin and out-of-DPS releases of steelhead in the Napa River basin in the 1970s and 80s. These transfers included fish from the South Fork Eel River, San Lorenzo River, Mad River, Russian River, and the Sacramento River.

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[2] Population as defined by Bjorkstedt *et al.* 2005 and McElhaney *et al.* 2000 as, in brief summary, a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream. These authors use this definition as a starting point from which they define four types of populations (not all of which are mentioned here).

In San Francisco Bay streams, reduced population sizes and fragmentation of habitat has likely also led to loss of genetic diversity in these populations. For more detailed information on trends in CCC steelhead abundance, see: Busby *et al.* 1996, NMFS 1997, Good *et al.* 2005, and Spence *et al.* 2008.

CCC steelhead have experienced serious declines in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead immigrants to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead remain present in most streams throughout the DPS, roughly approximating the known historical range, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid DPSs or ESUs in worse condition. In 2005, a status review concluded that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Good *et al*. 2005). On January 5, 2006, NMFS issued a final determination that the CCC steelhead DPS is a threatened species, as previously listed (71 FR 834).

A more recent viability assessment of CCC steelhead concluded that populations in watersheds that drain to San Francisco Bay are highly unlikely to be viable, and that the limited information available did not indicate that any other CCC steelhead populations could be demonstrated to be viable (Spence *et al.* 2008). Viable populations have a high probability of long-term persistence (> 100 years). Monitoring data from the last ten years of adult CCC steelhead returns in Lagunitas and Scott creeks show steep declines in adults in 2008/2009. In 2011/2012 population levels began to increase, but still remained lower than levels observed over the past ten years (The Nature Conservancy 2013). The most recent status update found that the status of the CCC steelhead DPS remains "likely to become endangered in the foreseeable future" (Williams *et al*. 2011), as new and additional information available since Good *et al.* (2005), does not appear to suggest a change in extinction risk. On December 7, 2011, NMFS chose to maintain the threatened status of the CCC steelhead (76 FR 76386).

Critical habitat was designated for CCC steelhead on September 2, 2005 (70 FR 52488) and includes PCEs essential for the conservation of CCC steelhead. Critical habitat in estuaries is defined by the perimeter of the waterbody as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater. These PCEs include estuarine areas free of obstruction and excessive predation with the following essential features: (1) water quality, water quantity and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (2) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (3) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation (70 FR 52488).

The condition of CCC steelhead critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid populations. NMFS has determined that present depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat: logging, agricultural and mining activities, urbanization, stream channelization, dams, wetland loss, and water withdrawals, including unscreened diversions for irrigation. Impacts of concern include alteration of streambank and channel morphology, alteration of water temperatures, loss of spawning and rearing habitat, fragmentation of habitat, loss of downstream recruitment of spawning gravels and large woody debris, degradation of water quality, removal of riparian vegetation resulting in increased streambank erosion, loss of shade (higher water temperatures) and loss of nutrient inputs (Busby *et al.* 1996, 70 FR 52488). Water development has drastically altered natural hydrologic cycles in many of the streams in the DPS. Alteration of flows results in migration delays, loss of suitable habitat due to dewatering and blockage; stranding of fish from rapid flow fluctuations; entrainment of juveniles into poorly screened or unscreened diversions, and increased water temperatures harmful to salmonids. Overall, current condition of CCC steelhead critical habitat is degraded, and does not provide the full extent of conservation value necessary for the recovery of the species.

2.2.1.3 Status of the CCV Steelhead DPS

California Central Valley (CCV) steelhead historically were well-distributed throughout the Sacramento and San Joaquin rivers (Busby *et al.* 1996). Although it appears CCV steelhead remain widely distributed in Sacramento River tributaries, the vast majority of historical spawning areas are currently above impassable dams. At present, all CCV steelhead are considered winter-run steelhead (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento River system prior to the commencement of large-scale dam construction in the 1940s (IEP 1999). McEwan and Jackson (1996) reported that wild steelhead stocks appear to be mostly confined to upper Sacramento River tributaries such as Antelope, Deer, and Mill creeks and the Yuba River. However, naturally spawning populations are also known to occur in Butte Creek, and the upper Sacramento mainstem, Feather, American, Mokelumne, and Stanislaus rivers (CALFED 2000). It is possible that other small populations of naturally spawning steelhead exist in Central Valley streams, but are undetected due to lack of sufficient monitoring and research programs; increases in fisheries monitoring efforts led to the discovery of steelhead populations in streams such as Auburn Ravine and Dry Creek (IEP 1999).

Small self-sustaining populations of CCV steelhead exist in the Stanislaus, Mokelumne, Calaveras, and other tributaries of the San Joaquin River (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 (Demko *et al*. 2000). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005).

Steelhead counts at the Red Bluff Diversion Dam (RBDD) have declined from an average annual count of 11,187 adults for the ten-year period beginning in 1967, to an average annual count 2,202 adults in the 1990's (McEwan and Jackson 1996). Estimates of the adult steelhead population composition in the Sacramento River (natural origin versus hatchery origin) have also changed over this time period; through most of the 1950's, Hallock *et al*. (1961) estimated that 88 percent of returning adults were of natural origin, and this estimate declined to 10-30 percent in the 1990's (McEwan and Jackson 1996). Furthermore, the California Fish and Wildlife Plan estimated a total run size of about 40,000 adults for the entire Central Valley, including San Francisco Bay, in the early 1960s (CDFG 1965). In 1991-92, this run was probably less than 10,000 fish based on dam counts, hatchery returns and past spawning surveys (McEwan and Jackson 1996).

The status of CCV steelhead appears to have worsened since the 2005 status review (Good *et al*. 2005), when the Biological Review Team (BRT) concluded that the DPS was in danger of extinction. New information available since Good *et al*. (2005) indicates an increased extinction risk (Williams *et al*. 2011). Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DPS focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery production of introduced steelhead within this DPS also raises concerns about the potential ecological interactions between introduced and native stocks. Because the CCV steelhead population has been fragmented into smaller isolated tributaries without any large source population, and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines. Based on this information, NMFS chose to maintain the threatened listing for this species (76 FR 50447), but recommends reviewing CCV steelhead status again in 2-3 years, (instead of the normal 5 years) if species numbers do not improve (NMFS 2011).

2.2.1.4 CV Spring-run and Sacramento River Winter-run Chinook Salmon General Life History

Chinook salmon return to freshwater to spawn when they are 3 to 8 years old (Healey 1991). Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and actual time of spawning (Myers *et al*. 1998). Both winter-run and spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991). Adult endangered Sacramento River winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985), and delay spawning until spring or early summer. Adult threatened Central Valley spring-run Chinook salmon enter the Sacramento-San Joaquin Delta (Delta) beginning in January and enter natal streams from March to July (Myers *et al*. 1998). Central Valley spring-run Chinook salmon adults hold in freshwater over summer and spawn in the fall. Central Valley spring-run Chinook salmon juveniles typically spend a year or more in freshwater before migrating toward the ocean. Adequate instream flows and cool water temperatures are more critical for the survival of Central Valley spring-run Chinook salmon due to over summering by adults and/or juveniles.

Sacramento River winter-run Chinook salmon spawn primarily from mid-April to mid-August, peaking in May and June, in the Sacramento River reach between Keswick Dam and the Red Bluff Diversion Dam. Central Valley spring-run Chinook salmon typically spawn between September and October depending on water temperatures. Chinook salmon generally spawn in waters with moderate gradient and gravel and cobble substrates. Eggs are deposited within the gravel where incubation, hatching, and subsequent emergence take place. The upper preferred water temperature for spawning adult Chinook salmon is 13^{o}C (Chambers 1956) to 14 ^{o}C (Reiser and Bjornn 1979). The length of time required for eggs to develop and hatch is dependent on water temperature, and quite variable.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994). Juvenile winter-run Chinook salmon spend 4 to 7 months in freshwater prior to migrating to the ocean as smolts. Central Valley spring-run Chinook salmon fry emerge from November to March and spend about 3 to 15 months in freshwater prior to migrating towards the ocean (Kjelson *et al*. 1981). Post-emergent fry seek out shallow, nearshore areas with slow current and good cover, and begin feeding on small terrestrial and aquatic insects and crustaceans. Chinook fry and parr may spend time rearing within riverine and/or estuarine habitats including natal tributaries, the Sacramento River, non-natal tributaries to the Sacramento River, and the Delta.

Within estuarine habitat, juvenile rearing Chinook salmon movements are generally dictated by 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 (Healey 1991; Levings 1982; Levy and Northcote 1982). Juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels and sloughs (Dunford 1975; McDonald 1960). 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). Kjelson *et al*. (1981) 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. Juvenile Sacramento River winter-run Chinook salmon migrate to the sea as smolts after only rearing in freshwater for 4 to 7 months, and occur in the Delta from October through early May (CDFG 2000). Most Central Valley spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 1998).

2.2.1.5 Status of the CV Spring-run Chinook Salmon

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon. Extensive construction of dams throughout the Sacramento-San Joaquin basin has reduced the Central Valley spring-run Chinook salmon run to only a small portion of its historical distribution. The Central Valley drainage as a whole is estimated to have supported Central Valley spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The ESU has been reduced to only three naturally-spawning populations that are free of hatchery influence from an estimated 17 historic populations.[3] These three populations (spawning in three tributaries to the Sacramento River - Deer, Mill, and Butte creeks), are in close geographic proximity, increasing the ESU's vulnerability to disease or catastrophic events.

Central Valley spring-run Chinook salmon from the Feather River Hatchery (FRH) were included in the ESU because they are believed by NMFS to be the only population in the ESU that displays early run timing. This early run timing is considered by NMFS to represent an important evolutionary legacy of the spring-run populations that once spawned above Oroville Dam (70 FR 37160). The FRH population is closely related genetically to the natural Feather River population. The FRH's goal is to release five million spring-run Chinook salmon per year. Recent releases have ranged from about one-and-a-half to five million fish, with most releases below five million fish (Good *et al*. 2005).

Several actions have been taken to improve habitat conditions for Central Valley spring-run Chinook salmon, including: habitat restoration efforts in the Central Valley; and changes in freshwater harvest management measures. Although protective measures likely have contributed to recent increases in Central Valley spring-run Chinook salmon abundance, the ESU is still well below levels observed from the 1960s. Threats from climatic variation, high temperatures, predation, and water diversions still persist. Hatchery production can also pose a threat to salmonids. Potential adverse effects from hatchery production include competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization. Despite these potential impacts from hatchery production, NMFS ultimately concluded the FRH stock should be included in the Central Valley spring-run Chinook ESU because it still exhibited a spring-run migration timing and was the best opportunity for restoring a more natural spring-run population in the Feather River. In the most recent status review of this ESU, NMFS concluded that the FRH stock should be considered part of the Central Valley spring-run Chinook ESU (Williams *et al*. 2011). Because wild Central Valley spring-run Chinook salmon ESU populations are confined to relatively few remaining watersheds and continue to display broad fluctuations in abundance, the BRT concluded that the ESU is likely to become endangered within the foreseeable future. The most recent status review concludes the status of Central Valley spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review (Williams *et al.* 2011). New information available since Good *et al.* (2005) indicates an increased extinction risk. Based on this information, NMFS has chosen to maintain the threatened listing for this species (76 FR 50447), but recommends reviewing Central Valley spring-run Chinook status again in 2-3 years, (instead of the normal 5 years) if species numbers do not improve (NMFS 2011).

2.2.1.6 Status of the Sacramento River Winter-Run Chinook Salmon and Critical Habitat

The Sacramento River winter-run Chinook salmon ESU has been completely displaced from its historical spawning habitat by the construction of Shasta and Keswick dams. Approximately,

[3] There has also been a small run in Big Chico Creek in recent years (Good *et al.* 2005).

300 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to the ESU. Most components of the Sacramento River winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. The only remaining spawning habitat in the upper Sacramento River is between Keswick Dam and Red Bluff Diversion Dam (RBDD). This habitat is artificially maintained by cool water releases from Shasta and Keswick Dams, and the spatial distribution of spawners in the upper Sacramento River is largely governed by the water year type and the ability of the Central Valley Project to manage water temperatures in this area.

Sacramento River winter-run Chinook salmon were first listed as threatened in 1989 under an emergency rule. In 1994, NMFS reclassified the ESU as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its listing as a threatened species in 1989; (2) the expectation of weak returns in coming years as the result of two small year classes (1991 and 1993); and (3) continuing threats to the species. NMFS issued a final listing determination on June 28, 2005. Between the time Shasta Dam was built and the Sacramento River winter-run Chinook salmon were listed in 1989, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at the RBDD, water exports in the southern Delta, and entrainment at a large number of unscreened or poorly-screened water diversions. However, the naturally spawning component of this ESU has exhibited marked improvements in abundance and productivity in the 2000s (CDFG 2008). These increases in abundance are encouraging, relative to the years of critically low abundance of the 1980s and early 1990s; however, returns of several West Coast Chinook salmon and coho salmon stocks were lower than expected in 2007 (NMFS 2008), and stocks remained low through 2009.

A captive broodstock artificial propagation program for Sacramento River winter-run Chinook salmon has operated since the early 1990s as part of recovery actions for this ESU. As many as 150,000 juvenile salmon have been released by this program, but in most cases the number of fish released was in the tens of thousands (Good *et al*. 2005). NMFS reviewed this hatchery program in 2004 and concluded that as much as 10 percent of the natural spawners may be attributable to the program's support of the population (69 FR 33102). The artificial propagation program has contributed to maintaining diversity through careful use of methods that ensure genetic diversity. If improvements in natural production continue, the artificial propagation program may be discontinued (69 FR 33102).

Critical habitat was designated for the Sacramento River winter-run Chinook salmon on June 16, 1993. Physical and biological features that are essential for the conservation of Sacramento winter-run Chinook salmon, based on the best available information, include: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River; (2) the availability of clean gravel for spawning substrate; (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles; (4) water temperatures between 6 and 14˚C for successful spawning, egg incubation, and fry development; (5) habitat areas and adequate prey that are not contaminated; (6) riparian areas that provide for successful juvenile development and survival; and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean (58 FR 33212).

Designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam, Shasta County (River Mile 302) to Chipps Island (River Mile 0), all waters from Chipps Island westward to Carquinez Bridge, all waters of San Pablo Bay, and all water of San Francisco Bay (north of the San Francisco /Oakland Bay Bridge). Winter-run Chinook salmon critical habitat has been degraded from conditions known to support viable salmonid populations. It does not provide the full extent of conservation values necessary for the recovery of the species. In particular, adequate river flows and water temperatures have been impacted by human actions, substantially altering the historical river characteristics in which the Sacramento River winter-run Chinook salmon evolved. Depletion and storage of stream flows behind large dams on the Sacramento River and other tributary streams have drastically altered the natural hydrologic cycles of the Sacramento River and Delta. Alteration of flows results in migration delays, loss of suitable habitat due to dewatering and blockage; stranding of fish from rapid flow fluctuations; entrainment of juveniles into poorly screened or unscreened diversions, and increased water temperatures harmful to salmonids. Other impacts of concern include alteration of stream bank and channel morphology, loss of riparian vegetation, loss of spawning and rearing habitat, fragmentation of habitat, loss of downstream recruitment of spawning gravels, degradation of water quality, and loss of nutrient input.

Several actions have been taken to improve habitat conditions for Sacramento River winter-run Chinook salmon, including: changes in ocean and inland fishing harvest that to increase ocean survival and adult escapement, and implementation of habitat restoration efforts throughout the Central Valley. However, this population remains below established recovery goals and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In addition to concern for catastrophic events that could affect the one remaining population, there is particular concern about risks to the ESU’s genetic diversity (genetic diversity is probably limited because there is only one remaining population) life-history variability, local adaptation, and spatial structure (Good *et al*. 2005, 70 FR 37160). The status of Sacramento River winter-run Chinook salmon is little changed since the last status review (Good *et al*. 2005), and new information available since does not appear to suggest a change in extinction risk (Williams *et al*. 2011). On August 15, 2011, NMFS reaffirmed no change to the listing of endangered for the Sacramento River winter-run Chinook salmon ESU (76 FR 50447).

2.2.1.7 Green Sturgeon General Life History

Green sturgeon is an anadromous, long-lived, and bottom-oriented fish species in the family Acipenseridae. Sturgeon have skeletons composed mostly of cartilage and lack scales, instead possessing five rows of characteristic bony plates on their body called "scutes." On the underside of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Large adults may exceed 2 meters in length and 100 kilograms in weight (Moyle 1976). Based on genetic analyses and spawning site fidelity, NMFS determined that North American green sturgeon are comprised of at least two DPSs: a northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River ("northern DPS green sturgeon"), with spawning confirmed in the Klamath and Rogue river systems; and a southern DPS consisting of populations originating from coastal watersheds south of the Eel River ("southern DPS green sturgeon"), with spawning confirmed in the Sacramento River system (Adams *et al*. 2002).

Green sturgeon is the most marine-oriented species of sturgeon (Moyle 2002). Along the West Coast of North America, they range in nearshore waters from Mexico to the Bering Sea (Adams *et al*. 2002), with a general tendency to head north after their out-migration from freshwater (Lindley *et al*. 2011). While in the ocean, archival tagging indicates that green sturgeon occur in waters between 0 and 200 meters depth, but spend most of their time in waters between 20–80 meters and temperatures of 9.5–16.0°C (Huff *et al*. 2011; Nelson *et al*. 2010). Subadult and adult green sturgeon move between coastal waters and estuaries, but relatively little is known about how green sturgeon use these habitats (Lindley *et al*. 2011). Lindley *et al*. (2011) report multiple rivers and estuaries are visited by aggregations of green sturgeon in summer months, and larger estuaries (e.g., San Francisco Bay) appear to be particularly important habitat. During the winter months, green sturgeon generally reside in the coastal ocean. Areas north of Vancouver Island are favored overwintering areas, with Queen Charlotte Sound and Hecate Strait likely destinations based on detections of acoustically-tagged green sturgeon (Lindley *et al*. 2008; Nelson *et al*. 2010).

Based on genetic analysis, Israel *et al*. (2009) reported that almost all green sturgeon collected in the San Francisco Bay system were southern DPS. This is corroborated by tagging and tracking studies which found that no green sturgeon tagged in the Klamath or Rogue rivers (i.e., Northern DPS) have yet been detected in San Francisco Bay (Lindley *et al*. 2011). However, green sturgeon inhabiting coastal waters adjacent to San Francisco Bay include northern DPS green sturgeon.

Adult southern DPS green sturgeon spawn in the Sacramento River watershed during the spring and early summer months (Moyle *et al*. 1995). Eggs are laid in turbulent areas on the river bottom and settle into the interstitial spaces between cobble and gravel (Adams *et al*. 2007). Like salmonids, green sturgeon require cool water temperatures for egg and larval development, with optimal temperatures ranging from 11 to 17˚C (Van Eenennaam *et al*. 2006). Eggs hatch after 6–8 days, and larval feeding begins 10–15 days post-hatch. Metamorphosis of larvae into juveniles typically occurs after a minimum of 45 days (post-hatch) when fish have reached 60–80 mm total length (TL). After hatching larvae migrate downstream and metamorphose into juveniles. Juveniles spend their first few years in the Sacramento-San Joaquin Delta (Delta) and San Francisco Estuary before entering the marine environment as subadults. Juvenile green sturgeon salvaged at the State and Federal water export facilities in the southern Delta are generally between 200 mm and 400 mm TL (Adams *et al*. 2002) which suggests southern DPS green sturgeon spend several months to a year rearing in freshwater before entering the Delta and San Francisco Estuary. Laboratory studies conducted by Allen and Cech (2007) indicated juveniles approximately 6-month old were tolerant of saltwater, but approximately 1.5-year old green sturgeon appeared more capable of successful osmoregulation in salt water.

Subadult green sturgeon spend several years at sea before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto *et al*. 1995). Little data are available regarding the size and age-at-maturity for the southern DPS green sturgeon, but it is likely similar to that of the northern DPS. Male and female green sturgeon differ in age-at-maturity. Males can mature as young as 14 years and female green sturgeon mature as early as age 16 (Van Eenennaam *et al*. 2006). Adult green sturgeon are believed to spawn every two to five years. Recent telemetry studies by Heublein *et al*. (2009) indicate adults typically enter San Francisco Bay from the ocean and begin their upstream spawning migration between late February and early May. These adults on their way to spawning areas in the upper Sacramento River typically migrate rapidly through the estuary toward their upstream spawning sites. Preliminary results from tagged adult sturgeon suggest travel time from the Golden Gate to Rio Vista in the Delta is generally 1-2 weeks. Post-spawning, Heublein *et al*. (2009) reported tagged southern DPS green sturgeon displayed two outmigration strategies; outmigration from Sacramento River prior to September 1 and outmigration during the onset of fall/winter stream flow increases. The transit time for post-spawning adults through the San Francisco Estuary appears to be very similar to their upstream migration (i.e., 1-2 weeks).

During the summer and fall, an unknown proportion of the population of non-spawning adults and subadults enter the San Francisco Estuary from the ocean for periods ranging from a few days to 6 months (Lindley *et al*. 2011). Some fish are detected only near the Golden Gate, while others move as far inland as Rio Vista in the Delta. The remainder of the population appear to enter bays and estuaries farther north from Humboldt Bay, California to Grays Harbor, Washington (Lindley *et al*. 2011).

Green sturgeon feed on benthic invertebrates and fish (Adams *et al*. 2002). Radtke (1966) analyzed stomach contents of juvenile green sturgeon captured in the Sacramento-San Joaquin Delta and found the majority of their diet was benthic invertebrates, such as mysid shrimp and amphipods (Corophium *spp*). Manual tracking of acoustically-tagged green sturgeon in the San Francisco Bay estuary indicates they are generally bottom-oriented, but make occasional forays to surface waters, perhaps to assist their movement (Kelly *et al*. 2007). Dumbauld *et al*. (2008) report that immature green sturgeon found in Willapa Bay, Grays Harbor, and the Columbia River Estuary, fed on a diet consisting primarily of benthic prey and fish common to these estuaries (ghost shrimp, crab, and crangonid shrimp), with burrowing thalassinid shrimp representing a significant proportion of the sturgeon diet. Dumbauld *et al*. (2008) observed feeding pits (depressions in the substrate believed to be formed when green sturgeon feed) in soft-bottom intertidal areas where green sturgeon are believed to spend a substantial amount foraging.

2.2.1.8 Status of Southern DPS Green Sturgeon and Critical Habitat

To date, little population-level data have been collected for green sturgeon. In particular, there are no published abundance estimates for either northern DPS or southern DPS green sturgeon in any of the natal rivers based on survey data. As a result, efforts to estimate green sturgeon population size have had to rely on sub-optimal data with known potential biases. Available abundance information comes mainly from four sources: 1) incidental captures in the California Department of Fish and Wildlife (CDFW) white sturgeon monitoring program; 2) fish monitoring efforts associated with two diversion facilities on the upper Sacramento River; 3) fish salvage operations at the water export facilities on the Sacramento-San Joaquin Delta; and 4) dual frequency sonar identification in spawning areas of the upper Sacramento River. These data are insufficient in a variety ways (short time series, non-target species, etc.) and do not support more than a qualitative evaluation of changes in green sturgeon abundance.

CDFW's white sturgeon monitoring program incidentally captures southern DPS green sturgeon. Trammel nets are used to capture white sturgeon and CDFW (CDFG 2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the size of subadult and adult sturgeon population. By comparing ratios of white sturgeon to green sturgeon captures, estimates of southern DPS green sturgeon abundance can be calculated. Estimated abundance of green sturgeon between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. For larval and juvenile green sturgeon in the upper Sacramento River, information is available from salmon monitoring efforts at the RBDD and the Glenn-Colusa Irrigation District (GCID). Incidental capture of larval and juvenile green sturgeon at the RBDD and GCID have ranged between 0 and 2,068 green sturgeon per year (Adams *et al*. 2002). Genetic data collected from these larval green sturgeon suggest that the number of adult green sturgeon spawning in the upper Sacramento River remained roughly constant between 2002 and 2006 in river reaches above Red Bluff (Israel and May 2010). In 2011, rotary screw traps operating in the Upper Sacramento River at RBDD captured 3,700 larval green sturgeon which represents the highest catch on record in 16 years of sampling (Poytress *et al*. 2011).

Juvenile green sturgeon are collected at water export facilities operated by the California Department of Water Resources (DWR) and the Federal Bureau of Reclamation (BOR) in the Sacramento-San Joaquin Delta. Fish collection records have been maintained by DWR from 1968 to present and by BOR from 1980 to present. The average number of southern DPS green sturgeon taken per year at the DWR facility prior to 1986 was 732; from 1986 to 2001, the average per year was 47 (70 FR 17386). For the BOR facility, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). Direct capture in the salvage operations at these facilities is a small component of the overall effect of water export facilities on southern DPS green sturgeon; entrained juvenile green sturgeon are exposed to potential high levels of predation by non-native predators, disruption in migratory behavior, and poor habitat quality. Delta water exports have increased substantially since the 1970s and it is likely that this has contributed to negative trends in the abundance of migratory fish that utilize the Delta, including the southern DPS green sturgeon.

During the spring and summer spawning period, researchers with University of California Davis have utilized dual-frequency identification sonar (i.e., DIDSON) to count adult green sturgeon in the upper Sacramento River. These surveys estimated 175 to 250 sturgeon (±50) in the mainstem Sacramento River during the 2010 and 2011 spawning seasons (Mora, personal communication, January 2012). However, it is important to note that this estimate may include some white sturgeon, and movements of individuals in and out of the survey area confound these estimates. Given these uncertainties, caution must be taken in using these estimates to infer the spawning run size for the Sacramento River, until further analyses are completed.

The most recent status review update concluded the southern DPS green sturgeon is likely to become endangered in the foreseeable future due to the substantial loss of spawning habitat, the concentration of a single spawning population in one section of the Sacramento River, and multiple other risks to the species such as stream flow management, degraded water quality, and introduced species (NMFS 2005). Based on this information, the southern DPS green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757).

Critical habitat was designated for the southern DPS of green sturgeon on October 9, 2009 (74 FR 52300) and includes coastal marine waters within 60 fathoms depth from Monterey Bay, California to Cape Flattery, Washington, including the Strait of Juan de Fuca to its United States boundary. Designated critical habitat also includes the Sacramento River, lower Feather River, lower Yuba River, Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay in California. PCEs of designated critical habitat in estuarine areas are food resources, water flow, water quality, mitigation corridor, depth, and sediment quality. In freshwater riverine systems, PCEs of green sturgeon critical habitat are food resources, substrate type or size, water flow, water quality, migratory corridor, depth, and sediment quality. In nearshore coastal marine areas, PCEs are migratory corridor, water quality, and food resources.

The current condition of critical habitat for the southern DPS of green sturgeon is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat of the Sacramento River. In the Sacramento River, migration corridor and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the southern DPS of green sturgeon evolved. In addition, the alterations to the Sacramento-San Joaquin River Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to their protracted rearing time in brackish and estuarine waters.

2.2.2 Factors Responsible for Steelhead, Chinook Salmon, and Green Sturgeon Stock Declines

NMFS cites many reasons (primarily anthropogenic) for the decline of steelhead (Busby *et al*. 1996), Chinook salmon (Myers *et al*. 1998), and southern DPS of green sturgeon (Adams *et al*. 2002; NMFS 2005). The foremost reason for the decline in these anadromous populations is the degradation and/or destruction of freshwater and estuarine habitat. Additional factors contributing to the decline of these populations include: commercial and recreational harvest, artificial propagation, natural stochastic events, marine mammal predation, reduced marine-derived nutrient transport, and ocean conditions.

2.2.2.1 Habitat Degradation and Destruction

The best scientific information presently available demonstrates a multitude of factors, past and present, have contributed to the decline of west coast salmonids and green sturgeon by reducing and degrading habitat by adversely affecting essential habitat features. Most of this habitat loss and degradation has resulted from anthropogenic watershed disturbances caused by urban development, agriculture, poor water quality, water resource development, dams, gravel mining, forestry (Adams *et al*. 2002; Busby *et al*. 1996; Good *et al*. 2005), and lagoon management (Bond 2006; Smith 1990).

2.2.2.2 Commercial and Recreational Harvest

Until recently, commercial and recreational harvest of southern DPS green sturgeon was allowed under State and Federal law. The majority of these fisheries have been closed (NMFS 2005). Ocean salmon fisheries off California are managed to meet the conservation objectives for certain stocks of salmon listed in the Pacific Coast Salmon Fishery Management Plan, including any stock that is listed as threatened or endangered under the ESA. Early records did not contain quantitative data by species until the early 1950's. In addition, the confounding effects of habitat deterioration, drought, and poor ocean conditions on salmonids make it difficult to assess the degree to which recreational and commercial harvest have contributed to the overall decline of salmonids and green sturgeon in West Coast rivers.

2.2.2.3 Artificial Propagation

Releasing large numbers of hatchery fish can pose a threat to wild salmon and steelhead stocks through genetic impacts, competition for food and other resources, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991).

2.2.2.4 Natural Stochastic Events

Natural events such as droughts, landslides, floods, and other catastrophes have adversely affected salmonid and sturgeon populations throughout their evolutionary history. The effects of these events are exacerbated by anthropogenic changes to watersheds such as logging, roads, and water diversions. These anthropogenic changes have limited the ability of salmonid and sturgeon to rebound from natural stochastic events and depressed populations to critically low levels.

2.2.2.5 Marine Mammal Predation

Predation is not known to be a major factor contributing to the decline of West Coast salmon and steelhead and green sturgeon populations relative to the effects of fishing, habitat degradation, and hatchery practices. Predation may have substantial impacts in localized areas. Harbor seal

(*Phoca vitulina*) and California sea lion (*Zalophus californianus*) numbers have increased along the Pacific Coast (NMFS 1997).

In a peer reviewed study of harbor seal predation in the Alsea River Estuary of Oregon, the combined results of multiple methodologies led researchers to infer that seals consumed 21 percent (range equals 3 - 63 percent) of the estimated prespawning population of coho salmon. The majority of the predation occurred upriver, at night, and was done by a relatively small proportion of the local seal population (Wright *et al*. 2007). However, at the mouth of the Russian River, Hanson (1993) reported that the foraging behavior of California sea lions and harbor seals with respect to anadromous salmonids was minimal, and predation on salmonids appeared to be coincidental with the salmonid migrations rather than dependent upon them.

The Corps has observed Steller sea lion (*Eumetopias jubatus*) preying on white sturgeon at the Bonneville Dam tailrace (Tackley *et al*. 2008). This suggests that predation of green sturgeon by sea lions may also occur in confined areas like dam tailraces when both species are present.

2.2.2.6 Avian Predation

Avian predation on juvenile salmonids is an important source of mortality in freshwater and estuarine habitats when birds and salmonids overlap spatially and temporally. Frechette *et al*. (2013) estimate that the population of kingfishers foraging in the Scott Creek estuary have the potential to remove 3–17 percent of annual production, whereas mergansers had the potential to remove 5–54 percent of annual steelhead production in this Central California coast watershed. Observed predation rates by cormorants and terns on Columbia River subyearling Chinook ranges between 2-22 percent, in which more than 8 million lower Columbia River (tule) fall-run Chinook Salmon subyearlings released from hatcheries are estimated to be consumed by double-crested cormorants and terns annually (Sebring *et al*. 2013).

2.2.2.7 Reduced Marine-Derived Nutrient Transport

Marine-derived nutrients from adult salmon carcasses have been shown to be vital for the growth of juvenile salmonids and the surrounding terrestrial and riverine ecosystems (Bilby *et al*. 1996; Bilby *et al*. 1998; Gresh *et al*. 2000). Declining salmon and steelhead populations have resulted in decreased marine-derived nutrient transport to many watersheds. Nutrient loss may be contributing to the further decline of ESA-listed salmonid populations (Gresh *et al*. 2000).

2.2.2.8 Ocean Conditions

Recent evidence suggests poor ocean conditions played a significant role in the low number of returning adult fall run Chinook salmon to the Sacramento River in 2007 and 2008 (Lindley *et al*. 2009). Changes in ocean conditions likely affect ocean survival of all west coast salmonid populations (Good *et al*. 2005; Spence *et al*. 2008).

2.2.2.9 Global Climate Change

Another factor affecting the rangewide status of threatened Southern DPS of North American green sturgeon, threatened CCV steelhead, threatened Central Valley spring-run Chinook salmon, endangered Sacramento River winter-run Chinook salmon, and aquatic habitat at large is climate change. Impacts from global climate change are already occurring in California. For example, average annual air temperatures, heat extremes, and sea level have all increased in California over the last century (Kadir *et al.* 2013). Snow melt from the Sierra Nevada has declined (Kadir *et al.* 2013). However, total annual precipitation amounts have shown no discernable change (Kadir *et al.* 2013).

Modeling of climate change impacts in California suggests average summer air temperatures are expected to increase (Lindley *et al*. 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe *et al*. 2004). Total precipitation in California may decline; critically dry years may increase (Lindley *et al*. 2007; Schneider 2007). The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers *et al*. 2006). Wildfires are expected to increase in frequency and magnitude, by as much as 55 percent under the medium emissions scenarios modeled (Luers *et al*. 2006). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal California streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline.

For the California North Coast, some models show large increases (75 to 200 percent) in rainfall while other models show decreases of 15 to 30 percent (Hayhoe *et al*. 2004). Snowmelt contribution to runoff in the San Francisco Bay and San Joaquin Delta may decrease by about 20 percent per decade over the next century (Cloern *et al*. 2011). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures. Estuaries may also experience changes detrimental to salmonids and green sturgeon. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia *et al*. 2002). In marine environments, ecosystems and habitats important to sub adult and adult green sturgeon and salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Brewer and Barry 2008; Feely 2004; Osgood 2008; Turley 2008).

In the San Francisco Bay region, extreme warm temperatures generally occur in July and August, but as climate change takes hold, the occurrences of these events will likely begin in June and could continue to occur in September (Cayan *et al*. 2012). Interior portions of San Francisco Bay are forecasted to experience a threefold increase in the frequency of hot daytime and nighttime temperatures (heat waves) from the historical period (Cayan *et al*. 2012). Climate simulation models also predict that the San Francisco region will maintain its Mediterranean climate regime, but experience a higher degree of variability of annual precipitation during the next 50 years and years that are drier than the historical annual average during the middle and end of the twenty-first century. The greatest reduction in precipitation is forecasted to occur in March and April, with the core winter months remaining relatively unchanged (Cayan *et al*. 2012). The projections described above are for the mid to late 21st Century. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007; Santer *et al* 2011).

2.3 Environmental Baseline

The Environmental Baseline is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem in the action area. 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 impacts of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02).

2.3.1 Action Area Overview

The San Francisco Bay portion of the action area includes areas that will be directly affected by dredging and disposal operations as well as areas affected by noise and turbidity during dredging and disposal. San Francisco Bay is the largest estuary on the U.S. West Coast, and the second largest in the United States (Conomos *et al*. 1985). It encompasses four sub-embayments: Central Bay, Suisun Bay, San Pablo Bay, and the South Bay. These four sub-embayments combined cover a total surface area of approximately 488 square miles and are referred to in this biological opinion as the San Francisco Estuary (or “Bay”) (see Figure 1). Located about halfway up the California coast from the Mexican border, the San Francisco Estuary is the natural discharge point of 40 percent of California’s freshwater outflow. The climate is Mediterranean; most precipitation falls in winter and spring as rain throughout the Central Valley and as snow in the Sierra Nevada and Cascade mountain ranges. The Bay receives an average of greater than 90 percent of its freshwater influx from the Delta (Conomos *et al*. 1985), with the remainder coming from over 450 tributary drainages (McKee *et al*. 2013). It also receives inputs from stormwater runoff, and wastewater from municipal and industrial sources that vary in volume depending on the location and seasonal weather patterns. The freshwater outflow pattern is seasonal; highest outflow occurs in winter and spring. Local watersheds adjacent to the Bay contribute approximately 56 percent of the sediment delivered to the Bay, with the Delta and coastal sources contributing the remaining sediment supply (Barnard *et al*. 2013). Current and wave patterns in the action area are largely generated by the tides interacting with the bottom and shoreline configurations.

The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) has conducted long-term water quality monitoring in the Bay since 1994. The following excerpt from the 2004-2005 annual monitoring report (Oram 2005) describes the long-term (1993-2005) patterns of temperature, salinity, and suspended particulate material within the action area:

Fresh water flowing in through the Delta has a long-term mean salinity less than one part per thousand (ppt), a long-term mean temperature of approximately 16 deg C, and a long-term mean suspended particulate material (SPM) concentration of approximately 40 mg/L. Salinity increases and temperature decreases downstream towards Central Bay, where the long-term mean salinity is approximately 30 ppt and the long-term mean temperature is approximately 14.5 deg C. SPM initially increases downstream, reaching its long-term maximum in San Pablo Bay (approximately 65 mg/L), then decreases again towards Central Bay, where the longterm mean SPM is 10-20 mg/L.

Ambient turbidity conditions in San Francisco Bay are controlled by freshwater runoff and tidal cycles. San Francisco Bay is considered a naturally turbid estuary because of the influence of large river inputs of suspended particulates, mostly mineral sediments (Cloern and Jassby 2012). Following large storms, suspended sediment concentrations at the surface and bottom of San Francisco Bay have been observed to peak around 250 and 300 mg/L over a 5-day period, respectively (Schoelhammer 1996). Suspended sediment concentrations is greatest in spring when wind waves resuspend sediment delivered during high winter flows. As the supply of erodible sediment decreases (due to low freshwater input) into the summer and fall, suspended sediment concentrations also decreases (Schoellhamer 2002). While freshwater input and storms can result in significant seasonal variances in turbidity conditions in the Bay, tidal cycles are considered the primary physical factor driving variances in suspended sediment concentrations (Schoellhamer 2001). In San Francisco Bay, tides are semidiurnal (two high and two low tides per day), and have a range of about 5.5 ft in Suisun Bay and 6.5 ft at the Golden Gate and Central Bay.

Central Bay, Suisun Bay, San Pablo Bay, and the South Bay all have shallow areas with mud to sand bottom, and deeper channels with mainly sand bottom. The mean water depth of the Central Bay is approximately 40 feet while the South Bay, San Pablo Bay and Suisun Bay have mean depths of 16 feet or less. Shorelines vary from armored revetments to beaches to marsh, and all basins adjoin mainly urban and industrial areas. Most of the Bay floor is comprised of sand and mud, overlying metamorphic and sedimentary bedrock. Bottom sediments are mud-dominated in shallower, low tidal energy areas. Sand is prevalent in deeper high tidal energy areas, such as the deeper portions of Central Bay and Suisun Bay, particularly within the main tidal channels where large waveforms are present along the Bay floor (Barnard *et al*. 2013). Both wind and tidal currents are strong in many parts of the estuary. The Carquinez Strait and Golden Gate are narrow sections where the estuary penetrates the Coast Range and tidal currents are particular strong at these locations. Wind-driven waves throughout the estuary are particularly common during the summer and these waves re-suspend sediments and increase local turbidity. Salinity varies from freshwater values in Suisun Bay to oceanic values at the Golden Gate.

Outside the Golden Gate, the action area includes the San Francisco Main Ship Channel, the San Francisco Bar Channel Disposal Site (SF-8), and the nearshore zone off Ocean Beach. These areas are referred to in this biological opinion as the "nearshore" portion of the action area (see

Figure 1).   Further offshore, the action area includes ocean waters in the proximity of SF-DODS. SF-DODS is approximately 6 nautical miles west of the outer boundary of the Gulf of the Farallones National Marine Sanctuary, and approximately 49 nautical miles west of the Golden Gate (see Figure 1). Water depths at SF-DODS range between 8,000 and 10,000 feet (LTMS 1998).

Benthic species in the in-bay portion of the action area vary from Suisun Bay where freshwater-brackish species dominate the community to the Central Bay where marine species predominate. Freshwater-brackish species include oligochaetes, chironomids (midges), soft-shelled clams, so-called Asian clam species in the genus *Corbicula*, and amphipods (SFEP, 1992; Thompson *et al*., 2000). Farther west into San Pablo Bay, more estuarine conditions exist, and intertidal mud flats and marshes are extensive. Here, estuarine assemblages are prevalent. Common benthic species include ribbed mussels, Baltic clams, the introduced clam *Potamocorbula. amurensis*, California hornsnails, yellow shore crabs, amphipods, polychaete worms, and Bay mussels (*Mytilus* spp.). In the Central Bay, common benthic species consist of clams (including the overbite clam, *C. Amurensis* or *Corbula*), amphipods such as *Monocorophium* and *Ampelisca*, polychaete worms, and Bay mussels (SFEP, 1992). Mollusks comprise the greatest biomass of larger benthic species in the Bay (LTMS, 1998).

In the nearshore ocean portion of the action area, the benthic fauna includes various assemblages of polychaete worms, crustaceans (amphipods, crabs, and ostracods), molluscs (pelecypods, gastropods, and scaphopods); echinoderms (starfish, brittle stars, heart urchins, sea cucumber, and sea pens). Overall, the benthic community in the nearshore ocean portion of the action area is similar to those typically found in high-energy environments along the coast of Northern California.

The benthic community in the SF-DODS is composed of invertebrates that burrow in the substrate (benthic infauna), invertebrates that live on the surface of the substrate (epifauna), and fish that are closely associated with the substrate (demersal fish). The benthic community in the SF-DODS is found in depths ranging between 8,000 and 10,000 feet, where environmental conditions are relatively harsh due to low oxygen, low food abundance, no light, high pressure, and low temperature. As a result, the number of species and overall abundance of organisms in this area is relatively low compared to shallower areas on the continental shelf (LTMS, 1998). Benthic infauna at SF-DODS is dominated by polychaete worms and crustaceans such as amphipods. The epibenthic community is predominately composed of sea cucumbers, brittlestars, sea stars (echinoderms), and sea pens (cnidarians). Fifteen species of demersal fish have been collected in the SF-DODS region (LTMS, 1998). The most common species are rattails (Macrouridae), thornyheads (*Sebastolobus* sp.), finescale codling (*Antimora microlepis*), and eelpouts (Zoarcidae).

The action area of the LTMS Program consists of locations where maintenance dredging is conducted and dredged materials disposed within the San Francisco Bay Region. This comprises 11 federal navigation channels (Table 2 and Figure 1) and approximately 100 maintenance dredging sites associated with ports, marinas, and homeowners associations (Table 3 and Figure

1). There are seven in-water disposal locations that are currently in use: Ocean Disposal (SF-DODS); San Francisco Bar (SF-8); Carquinez Strait (SF-9); San Pablo Bay (SF-10); Alcatraz (SF-11); Suisun Bay (SF-16); and Ocean Beach Demonstration Site (SF-17) (Figure 1).

From 2000 to 2014, between 20 and 45 dredging episodes have been reviewed by the DMMO and authorized by the Corps annually. The Corps also typically dredges 6-8 federal navigation channels per year. Table 4 presents the total annual volume of dredged material disposed by location for both non-Corps projects and the Corps-dredged federal navigation channels. Table 2 presents the past Corps navigation channel dredging by location, equipment type, frequency of dredging, volumes dredged, and materials placement site.

Since 2000, the in-bay LTMS disposal volume reduction targets were successfully met for each 3-year increment of the transition period through 2012. To date, in-Bay disposal has been reduced from 6.0 million cubic yards per year pre-1990 to approximately 1.0 million cubic yards in 2013 (Table 4).

2.3.1.1 Federal Navigation Channels

The Corps currently conducts operations and maintenance dredging of federal navigation channels in San Francisco Bay, California in conformance with the LTMS Program. The 11 federally-authorized channels are listed in Tables 2 and 5. The total surface area of these channels is 4,866 acres which is approximately 1.98 percent of the total surface area of San Francisco Bay. Six channels are dredged annually and five channels have non-annual dredging cycles.

The navigation channels are deeper channels cut into the bay floor to enable vessels to pass through to a port or other destination. Authorized or regulatory depths range from -6 feet mean low low water (MLLW) in the San Rafael Canal to -55 feet in the San Francisco Main Ship Channel. Authorized or regulatory depths for the 11 federal navigation channels are presented in Table 5.

Bottom sediments in the federal navigation channels at Richmond Harbor, San Rafael Creek, Napa River Channel, Oakland Harbor, San Leandro Marina, and Redwood City Harbor are typically marine clay-silt deposit termed “bay mud”. Federal navigation channels at the San Francisco Main Ship Channel, Suisun Bay Channel/New York Slough, and portions of Pinole Shoal Channel typically contain sediments that are greater than 80 percent sand. The remaining portion of Pinole Shoal typically contains less than 80 percent sand.

2.3.1.2 Marinas and Harbors

The LTMS Program currently provides for maintenance dredging activities at marinas, harbors and boat ramps within the San Francisco Bay Region. There are in excess of 50 marinas and harbors within the action area (Figure 1). These facilities typically contain floating docks,

Table 4. Total Annual Volume of Dredged Material Disposed (includes both Corps and non-Corps projects)
Source: San Francisco Bay LTMS 12-Year Review, March 2012, and DMMO Annual Report 2013.

Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
In-Bay Disposal Total	880,000	2,041,936	1,887,083	1,890,000	1,312,829	1,473,253	1,816,866	1,249,338	1,512,098	1,107,859	1,139,780	1,661,074	821,153	987,268
SF-DODS Total	775,000	566,679	866,400	1,113,814	341,000	137,717	954,456	1,554,362	175,855	72,289	285,460	652,970	772,760	1,632,515
Upland Volume Total	2,294,676	1,028,256	650,051	646,337	869,452	4,718,716	1,558,487	1,527,549	2,587,097	2,688,264	591,595	971,368	1,014,561	553,066

Table 5. Authorized or Regulatory Depth (MLLW) of Federal Navigation Channels in SF Bay Region
Source: Federal Navigation Channels draft EA/EIR, December 2014.

Federal Channel	Depth (feet below MLLW)
Richmond – Inner Harbor	-20 to -41
Outer Harbor	-45
San Francisco Harbor – Main Ship Channel	-55
Napa River Channel/Mare Island	-15 to -35
Petaluma River Channel (and Across the Flats*)	-8
San Rafael Creek Channel	-6 to -8
Pinole Shoal	-35
Suisun Bay Channel and New York Slough	-25 to -35
Oakland Inner and Outer Harbor	-18 to -50
San Leandro Marina	-8
Redwood City Harbor	-30

pontoons, and other mooring facilities for boats. A few marinas in the action area are located along shorelines in natural harbors; however, most marinas were constructed by excavation of the shoreline, landfill, or a combination of both. Many have vessel refueling, washing and repair facilities. Marinas are typically confined by jetties or breakwater structures to shelter boats from the effects of wind and waves. Tidal water circulation is often restricted within a marina by the configuration of jetties and breakwaters. Marinas and harbors within the action are typically dredged to maintain depths of -8 to -15 feet MLLW. Bottom sediments are generally fine marine clay-silt deposits.

2.3.1.3 Ports, Wharfs and Docks

San Francisco Bay is a hub of international commerce and its maritime development is extensive. Major cargo facilities exist at the ports of Oakland, San Francisco and Redwood City. Several large oil refineries are located in the San Francisco Bay Region and rely on shipping to move their petroleum products. Many other major and minor industries around the bay have developed port and wharf facilities for shipping products. The LTMS Program currently provides for these areas to be periodically dredged for the navigation and berthing of large vessels, including oil tankers and cargo ships. The shoreline and adjacent aquatic habitat in these areas are highly modified with the construction of piers, wharfs, bulkheads, and placement of landfill. Aquatic vegetation is typically lacking in these areas. Bottom substrate is generally fine-grain silt and clay.

2.3.1.4 Disposal Sites

The four in-bay dredged material disposals sites at Carquinez Strait (SF-9), San Pablo Bay (SF-10), Alcatraz (SF-11), and Suisun Bay (SF-16) (Figure 1). The Carquinez Strait placement site is a 1,000-foot by 2,000-foot rectangle, approximately 10 to 55 feet deep, 0.9 mile west of the entrance to Mare Island Strait in eastern San Pablo Bay in Solano County. The San Pablo Bay placement site is a 1,500-foot by 3,000-foot rectangle, approximately 30 to 45 feet deep, 3.0 miles northeast of Point San Pedro in southern San Pablo Bay in Marin County. The Alcatraz placement site is a 1,000-foot-radius circular area, approximately 40 to 70 feet deep, approximately 0.3 mile south of Alcatraz Island in the Central Bay. Since at least 1972, SF-11 has been the most heavily used disposal site in San Francisco Bay. The Suisun Bay placement site is a single-user disposal site reserved for sand dredged by the Corps from the Suisun Channel and New York Slough projects only. The Suisun site is a 500-foot by 11,200-foot rectangle adjacent to the northern side of Suisun Bay Channel, approximately 1 mile upstream of the Interstate 680 Bridge. The depth at this site is approximately -30 feet MLLW.

The two nearshore disposal sites outside of the Golden Gate are San Francisco Bar Channel (SF-8) and Ocean Beach Nearshore/Demonstration site (SF-17). The San Francisco Bar Channel site is a 15,000- by 3,000-foot-wide rectangle 7,500 feet south of the San Francisco Bar Channel in the Pacific Ocean. Depths range from approximately -30 to -45 feet MLLW. Disposal is limited to sandy material dredged by Corps from the San Francisco Bar Channel. However, the easternmost portion of SF-8 is within the 3-mile limit, and sand from other San Francisco Bay Area dredging projects can be permitted there as beneficial reuse for beach nourishment.

The Ocean Beach Nearshore/Demonstration site is in waters of the Pacific Ocean adjacent to the south-of-Sloat-Boulevard stretch of Ocean Beach, and outside of the southern section of the San Francisco Bar. The site's eastern boundary is approximately 0.35 mile offshore from the back-beach bluff; its center is 4 miles southwest of SF-8; and the site's area is 3.3 square miles. Water depths along the shoreward boundary range from approximately -25 to -35 feet MLLW, and depths along the seaward boundary ranges from approximately -37 to greater than -50 feet MLLW. The Ocean Beach Demonstration site was selected due to its location where waves can potentially feed sediment toward Ocean Beach which may ultimately help mitigate ongoing shoreline erosion in the area.

The deepwater ocean disposal site at SF-DODS is 6.5-square nautical miles and located approximately 49 nautical miles west of the Golden Gate. It is the farthest offshore and deepest dredged materials disposal site in the United States. Water depths range for 8,000 to 10,000 feet. This disposal site is influenced by the California Current which is a broad offshore flow that transport cold, low-salinity, subarctic waters toward the equator. However, two northerly flows, the Coastal Countercurrent and the California Undercurrent also strongly influence the flow regime in the vicinity of the Farallon Islands. Semidiurnal and diurnal tides also account for a large amount of variability in currents offshore.

2.3.2 Status of Species and Critical Habitat in Action Area

The following sections provide a brief summary of the population and critical habitat status of each listed species within the action area.

2.3.2.1 CCC Steelhead, CCV Steelhead, CV Spring-Run Chinook Salmon, and Sacramento River Winter-Run Chinook Salmon

The action area is used primarily as a migration corridor by listed CCC steelhead, CCV steelhead, CV spring-run Chinook salmon and Sacramento River winter-run Chinook salmon. Adult salmonids migrate from the Pacific Ocean through the San Francisco Bay estuary as they seek the upstream spawning grounds of their natal streams. Adult CCV steelhead migration through the Bay typically begins in fall and winter (McEwan and Jackson 1996). Adult CCC steelhead typically migrate through San Francisco Bay to their natal streams from December through April. Adult Sacramento River winter-run Chinook migrate through San Francisco Bay between December and May. Based on time of entry to natal tributaries in the Central Valley, adult Central Valley spring-run Chinook salmon enter the Bay from the ocean for their upstream migration between February and April.

Juvenile (smolt) salmonids migrate from their natal streams through San Francisco Bay estuary to the ocean. Emigration timing is highly variable among Sacramento River winter-run Chinook, CV spring-run Chinook, CCC steelhead and CCV steelhead smolts, but peak migrations downstream typically occur through the action area during the late winter and spring months. To assess juvenile salmonid outmigration behavior and timing, a series of studies were performed from 2006 through 2010 with Central Valley late fall-run Chinook salmon and CCV steelhead smolts. Smolt-sized juveniles originating from Coleman National Fish Hatchery were tagged with acoustic transmitters and released in the Sacramento River to monitor their downstream movement to ocean-entry at the Golden Gate. Results showed that smolts generally transited the Bay rapidly in 2 to 4 days, y*et al*so made repeated upstream movements, coinciding with incoming tidal flows (Hearn *et al.* 2013). Most Chinook and steelhead smolts were detected by acoustic receivers located over deep, channelized portions of the Bay (Hearn *et al* 2013). Smolts detected at nearshore, shallow sites such as marinas, or up tributaries generally returned to the main channel to finish their migration (Hearn *et al.* 2013).

During the course of their downstream migration, juvenile listed salmon and steelhead may utilize the estuary for seasonal rearing, but available information suggests that fish are actively migrating and currently they do not reside in the San Francisco Bay estuary (Hearn *et al*. 2010). Historically, the tidal marshes of San Francisco Bay provided a highly productive estuarine environment for juvenile anadromous salmonids. However, loss of habitat, changes in prey communities, and water-flow alterations and reductions have degraded habitat and likely limit the ability of the Bay to support juvenile rearing. MacFarlane and Norton (2002) found that fall-run Chinook experienced little growth, depleted condition, and no accumulation of lipid energy reserves during the relatively limited time the fish spent transiting the 40-mile length of the estuary. Sandstrom *et al*. (2013) found that CCC steelhead smolts emigrated more rapidly through the Bay than the Napa River and the ocean.

In contrast to demersal fish that are associated with the channel bottom, salmonids are pelagic fish and, as such, primarily occupy the water column and near surface when over deeper waters (Mari-Gold Environmental and Novo Aquatic Sciences 2009). Within the action area, listed salmon and steelhead are thought to typically display a preferential use of the middle and upper water column. Studies by Kjelson *et al.* (1982) in the Sacramento-San Joaquin Delta concluded juvenile Chinook salmon appear to prefer shallow water habitats near the shore and the upper portion of the water column (less than 10 feet deep).

2.3.2.2 CCC Steelhead and Sacramento River Winter-Run Chinook Salmon Critical Habitat

The portion of the action area located in San Francisco and San Pablo bays is designated critical habitat for CCC steelhead. PCE's essential for the conservation of CCC steelhead include estuarine areas free of obstruction and excessive predation with: (1) water quality, water quantity and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (2) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (3) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation (70 FR 52488). Essential features of designated critical habitat for CCC steelhead in the action area include the estuarine water column, benthic foraging habitat, and food resources used by steelhead as part of their juvenile downstream migration and adult upstream migration. These essential features of estuarine PCEs of designated critical habitat within the action area are partially degraded and limited due to altered and diminished freshwater inflow, shoreline development, shoreline stabilization, non-native invasive species, discharge and accumulation of contaminants, loss of tidal wetlands, and periodic dredging for navigation.

The portion of the action area located in Suisun Bay, San Pablo and San Francisco Bay north of the San Francisco-Oakland Bay Bridge is designated critical habitat for Sacramento River winter-run Chinook salmon. Features of designated critical habitat for winter-run Chinook salmon in the action area essential for their conservation are habitat areas and adequate prey that are uncontaminated. These physical and biological features of designated critical habitat within the action area are degraded and limited. Habitat degradation in the action area is primarily due to altered and diminished freshwater inflow, shoreline development, shoreline stabilization, non-native invasive species, discharge and accumulation of contaminants, loss of tidal wetlands, and periodic dredging for navigation.

2.3.2.3 Green Sturgeon

Green sturgeon are iteroparous[4], and adults pass through the San Francisco Bay estuary during spawning, and post-spawning migrations. Pre-spawn green sturgeon enter the Bay between late

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[4] They have multiple reproductive cycles over their lifetime.

February and early May, as they migrate to spawning grounds in the Sacramento River (Heublein *et al*. 2009). Post-spawning adults may be present in the bay after spawning in the Sacramento River in the spring and early summer for months prior to emigrating into the ocean. Juvenile green sturgeon move into the Delta and San Francisco Estuary early in their juvenile life history, where they may remain for 2-3 years before migrating to the ocean (Allen and Cech 2007; Kelly *et al*. 2007). Sub-adult and non-spawning adult green sturgeon utilize both ocean and estuarine environments for rearing and foraging. Due to these life-history characteristics, juvenile, sub-adult and adult green sturgeon may be present in the action area year-round.

Little is known about green sturgeon distribution and abundance in the Bay, and what influences their movements (Kelly *et al*. 2007). Tracking of green sturgeon movements in the Bay indicate that sub-adults typically remain in shallower depths (less than 30 feet) and show no preference for temperature, salinity, dissolved oxygen, or light levels (Kelly *et al*. 2007). Observations also suggest that there are two main types of movements of sub-adult green sturgeon: directional and non-directional (Kelly *et al*. 2007). Tracking data suggests that directional movements typically occur near the surface of the water, while non-directional movements were associated with the bottom at depths up to 42 feet, indicating foraging behavior (Kelly *et al*. 2007) since green sturgeon are known to feed on benthic invertebrates and fish (Adams *et al*. 2002). Within the San Francisco Estuary, green sturgeon are encountered by recreational anglers and during sampling by CDFW in the shallow waters of San Pablo Bay. These fish are likely foraging on benthic prey and fish commonly found in soft-bottom habitats (ghost shrimp, crab, crangonid shrimp, and thalassinid shrimp) (Dumbauld *et al*. 2008).

As a demersal fish, green sturgeon are commonly associated with the channel bottom. Kelly *et al*. (2007) tracked the movements of several individual green sturgeon through the San Francisco Bay Estuary with ultrasonic telemetry. These observations concluded that non-directional movements, accounting for 63.4% of observations, were closely associated with the bottom, with individuals moving slowly while making frequent changes in direction and swim speed, or not moving at all. These non-direction movements recorded sturgeon swimming at bottom depths ranging from one foot to 80 feet; however, over 70% of sturgeon remained in shallow regions of the estuary less than 30 feet deep, and it was uncommon for sturgeon to swim at depths greater than 52 feet (Kelly *et al*. 2007). Directional movements, accounting for 36.6% of total observations, were typified by continuous and active swimming while holding a steady course for long periods of time. When all depth records from directional movements were grouped, Kelly *et al*. (2007) concluded that green sturgeon make directional movements near the water surface (in the upper 6 feet of the water column) and rarely ventured below 15 feet, despite the depth of the bottom exceeding 60 feet in depth.

The CDFW conducts regular surveys to estimate sturgeon (white and green) abundance, relative abundance, harvest rate, and survival rate in San Francisco Bay and the delta. They collect information from recreational and commercial fisherman as well as conduct annual sampling in Suisun and San Pablo bays. Data from 2012 and 2013 show that green sturgeon abundance is low in Suisun and San Pablo bays relative to white sturgeon abundance. Green sturgeon make up approximately 2-5 percent of the total reported sturgeon caught in the greater Bay and lower delta. Green sturgeon catches were highest in Suisun Bay and San Pablo Bay, with very few green sturgeon reported in Central San Francisco Bay. However, this may be due to variances in fishing efforts in different locations in the Bay. Nonetheless, based on the available data, NMFS believes green sturgeon abundance in the action area is low.

2.3.2.4 Green Sturgeon Critical Habitat

With the exception of the SF-DODS and upland disposal sites, the project's action area is located within designated critical habitat for the southern DPS of green sturgeon. PCEs for green sturgeon in estuarine areas are: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. These PCEs for green sturgeon critical habitat in the action area are degraded. Habitat degradation in the action area is primarily due to altered and diminished freshwater inflow, shoreline development, shoreline stabilization, non-native invasive species, discharge and accumulation of contaminants, loss of tidal wetlands, and periodic dredging for navigation.

2.3.3 Factors Affecting the Species Environment in the Action Area

The San Francisco Bay/Delta is one of the most human-altered estuaries in the world (Knowles and Cayan 2004). Major drivers of change in the Bay that are common to many estuaries are water consumption and diversion, human modification of sediment supply, introduction of nonnative species, sewage and other pollutant inputs, and climate shifts. Responses to these drivers in the Bay include shifts in the timing and extent of freshwater inflow and salinity intrusion, decreasing turbidity, restructuring of plankton communities, nutrient enrichment and metal contamination of biota, and large-scale food web changes (Cloern and Jassby 2012). Major factors affecting the species environment in the Bay are described below:

2.3.3.1 Reduced Amount and Altered Timing of Freshwater Flow

Following the gold rush of the mid 1800s, population growth and economic development in California required a stable water supply. Large water projects were developed to capture and transport runoff from wet regions to drier regions for agriculture and residential supplies (Nichols *et al*. 1986). Approximately 60 percent of runoff from the Delta and upstream watersheds reach the Bay (Cloern and Jassby 2012). Water exports from the Delta increased from 5 percent to 30 percent of the total runoff from the Delta between 1956 and 2003 (Cloern and Jassby 2012). In response to reduced freshwater flow, the salinity gradient in the Suisun Channel moves further upstream during the latter (i.e., drier) part of the year (Cloern and Jassby 2012). Researchers have identified several biological impacts of reduced inflow from the Delta to the Bay and altered salinity gradients in the North Bay, namely, large-scale population declines of native aquatic biota across trophic levels from phytoplankton (Alpine and Cloern 1992) to zooplankton (Winder *et al*. 2011) to pelagic fish (Sommer *et al*. 1997), and large shifts in biological communities (Winder and Jassby 2011).

2.3.3.2 Changes to Sediment Supply

Major historical changes to the estuary were driven by extensive hydraulic mining in the western foothills of the Sierra Nevada Mountain Range between 1850 and 1900, when over 850 million cubic meters (m^3) of sediment was discharged into watersheds that drain to the Bay (Gilbert 1917). Sediment influxes into the Bay from hydraulic mining resulted in the extensive ecosystem alterations, including the development of extensive intertidal flats and tidal marshes (i.e., centennial marshes) (Jaffe *et al*. 2007), and widespread mercury contamination (David *et al*. 2009). Logging, urbanization, agriculture, and grazing within Bay area watersheds since the 1850s have also lead to increased sediment yields and pollution in the Bay. At the same time, the construction of dams, reservoirs, flood control structures, and bank protection in watersheds draining to the Bay in the 20^{th} century have concurrently trapped and/or reduced the transport of sediment to the Bay and reduced peak flows that transport sediment to the Bay (Barnard *et al*. 2013). It is estimated that these modifications have resulted in an approximately 50 percent reduction in suspended sediment flux to the Bay from 1957 to 2001 (Wright and Schoellhamer 2004). Since the 1950s, sediment loss trends have been documented in Central Bay, Suisun Bay, San Pablo Bay, and the mouth of the San Francisco Bay (Capiella *et al*. 1999; Fregoso *et al*. 2008; Hanes and Barnard 2007). It is estimated that dredging, aggregate (sand) mining, and borrow pit mining has permanently removed 200 million m^3 of sediment from the Bay over the last century (Barnard and Kvitek 2010). Bathymetric change analysis has shown that accretion and erosion within sand mining lease areas follows decreases and increases in sand mining activity, respectively, however a direct relationship between sand mining activity and the overall sand budget in Central San Francisco Bay, the San Francisco Bar and the outer coast beaches is still unclear (Barnard 2014). Reduced sediment supply to the Bay may result in the exposure of legacy contaminants (e.g., mercury) as surface sediments continue to erode (Jaffe *et al*. 2007), as well as reduce the sediment available to build tidal marshes as sea level rises (Stralberg *et al*. 2011).

2.3.3.3 Contaminants

Sediments within the Bay contain a substantial amount of contaminants from historical point and non-point sources. Contaminants often times are bound to sediments, and thus their distribution within the environment is driven by sediment dynamics in the Bay. In some areas of the Bay, contaminated sediments are being buried by cleaner sediments; in other areas, contaminated sediments or clean sediments overlying contaminated sediments are eroding. Remobilization of buried contaminants can occur through erosion of sediments, which can lead to contamination of the surface of the sediment layer and the water column. This is of particular concern for many legacy contaminants (e.g., the pesticide DDT) that no longer are supplied to an estuary in large quantities, compared to historic inputs, but continue to persist because the bottom sediment acts as a source, as in the case of San Francisco Bay (Cloern and Jassby 2012).

2.3.3.4 Invasive Species and Ballast Water Effects

San Francisco Bay is considered one of the most invaded estuaries in the world (Cohen and Carlton 1998). Invasive species contribute up to 99 percent of the biomass of some of the communities in the Bay (Cloern and Jassby 2012). Invasive species can disrupt ecosystems that support native populations. While there have been numerous invasions in the Bay, the best documented and studied invasive is the non-native overbite clam *Corbula amurensis*. It is a small clam native to rivers and estuaries of East Asia that is believed to be introduced in the ballast waters of ships entering the Bay in the late 1980s. *C. amurensis* can utilize a broad suite of food resources and withstand a wide range of salinities, including a tolerance of salinities less than 1 ppt (Nichols *et al*. 1990). Its introduction has corresponded with a decline in phytoplankton and zooplankton abundance due to grazing by *C. amurensis* (Kimmerer *et al*. 1994). Prior to its introduction, phytoplankton biomass in the Bay was approximately three times what it is today (Cloern 1996; Cloern and Jassby 2012), and the zooplankton community has changed from one having large abundances of mysid shrimp, rotifers, and calanoid copepods to one dominated by copepods indigenous to East Asia (Winder and Jassby 2011).

The discharge of ballast water from large vessels (*i.e.,* container ships) is the major pathway for the introduction of invasive species in the San Francisco Estuary. Ballast water is taken on by a vessel to increase water draft, change the trim, regulate stability or maintain stress loads. When the ship reaches its destination, it commonly discharges ballast water containing the larvae of nonindigenous organisms. Under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 as reauthorized and amended in the National Invasive Species Act of 1996, the United States Coast Guard (USCG) is the lead federal agency in implementing regulations to reduce or prevent the introduction of nonindigenous species via shipping activities in United States waters. On March 23, 2012 the USCG publish in the Federal Register standards for living organisms in ship's ballast water discharged in U.S. waters. This standard which took effect in 2013 establishes an allowable concentration of living organisms in ship's ballast water discharges for the purpose of preventing or reducing the introduction of nonindigenous species. The USCG's program also requires vessel operators to maintain records and report their discharges. USCG has the ability to board vessels to ensure vessel operators are treating and discharging ballast water in compliance with all requirements.

The State of California has also adopted regulations to prevent and reduce the release of nonindigenous species from commercial vessels to California waters. The Marine Invasive Species Act of 2003 requires vessels to adopt a ballast water management plan and maintain ballast water activity records. California's multi-agency Marine Invasive Species Program (MISP) is comprised of the State Lands Commission, CDFW, State Water Resources Control Board and the Board of Equalization. The policy and regulations developed for the California by the MISP include the action area of this consultation and are considered by the State to be the most practicably achievable standards for avoiding the discharge of nonindigenous species. Although the recently adopted USCG and State of California ballast water discharge standards are likely effective in preventing and reducing the harmful introduction of new nonindigenous species, the current suite of exotic plants and aquatic animals living in San Francisco Bay persist.

2.3.3.5 Natural Ocean-Atmosphere Variations

Research indicates that the Bay is significantly influenced by ocean-atmosphere variations (i.e., the North Pacific Gyre Oscillation and the Pacific Decadal Oscillation). For example, following a strong El Nino event in 1997-1998 and an equally strong La Nina event in 1999, the ocean waters adjacent to San Francisco Bay cooled and upwelling intensity increased. Major changes in the Bay ensued, with record high populations of fish species that migrate from the ocean to the Bay (e.g. English sole, Dungeness crab). The increase in abundance of predators to the Bay led to large-scale trophic cascades in the Bay characteristic of a cool, high-production regime (Cloern and Jassby 2012). Such climate shifts occur at various intervals and have widespread implication on the annual mean abundance of biota in the Bay (see Figure 16: Cloern and Jassby 2012).

2.3.4 Previous Section 7 Consultations and Section 10 Permits in the Action Area

From 2000 through March 2015, pursuant to section 7 of the ESA, NMFS has conducted multiple interagency consultations within the action area of this project. These consultations were primarily related to sand mining, dredging, wetland restoration, shoreline stabilization, and maintenance of existing infrastructure along the shoreline (i.e. repair of wharves, docks and piers. For most of these projects NMFS determined that they were not likely to adversely affect listed salmonids or green sturgeon or their critical habitat. For those projects with adverse effects on listed salmonids and green sturgeon and/or critical habitat, NMFS determined that they were not likely to jeopardize the continued existence of listed salmonids or adversely modify critical habitat. Adverse effects that resulted from these projects are not anticipated to affect the current population status of listed salmonids or green sturgeon.

Research and enhancement projects resulting from NMFS' Section 10(a)(1)(A) research and enhancement permits and section 4(d) limits or exceptions could potentially occur in the action area. Salmonid and sturgeon monitoring approved under these programs includes juvenile and adult net surveys and tagging studies. In general, these activities are closely monitored and require measures to minimize take during the research activities. As of March 2015, no research or enhancement activities requiring Section 10(a)(1)(A) research and enhancement permits or section 4(d) limits have occurred in the action area.

2.4 Effects of the Action

The purpose of this section is to identify the direct and indirect effects of the proposed action, and any interrelated or interdependent activities, on CCC steelhead, CCV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and southern DPS green sturgeon; and designated critical habitat for Sacramento River winter-run Chinook salmon, CCC steelhead, and southern DPS green sturgeon. Our approach was based on knowledge and review of the ecological literature and other relevant materials. We used this information to gauge the likely effects of the proposed project via an exposure and response framework that focuses on what stressors (physical, chemical, or biotic), directly or indirectly caused by the proposed action, that salmonids and green sturgeon are likely to be exposed to. Next, we evaluated the likely response of salmonids and green sturgeon to these stressors in terms of changes to survival, growth, and reproduction, and changes to the ability of PCEs or physical and biological features to support the value of critical habitat in the action area. PCEs and physical and biological features, include sites essential to support one or more life stages of the species. These sites for migration, spawning, and rearing in turn contain physical and biological features that are essential to the conservation of the species. Where data to quantitatively determine the effects of the proposed action on salmonids, sturgeon, and their critical habitat, were limited or not available, our assessment of effects focused mostly on qualitative identification of likely stressors and responses.

2.4.1 Exposure to Dredge and Disposal Sites

The southern DPS of green sturgeon spawns in the upper Sacramento River system and all individuals must travel through the San Francisco Estuary to pass between the ocean and the Upper Sacramento River Basin. Additionally, the San Francisco Estuary provides important rearing and holding areas for juveniles, sub-adults and pre- and post-spawning adult green sturgeon. Threatened CCC steelhead that spawn within streams tributary to San Francisco, San Pablo and Suisun bays must also travel through the estuary to access the ocean as smolts and return as adults to their natal streams. For Central Valley listed anadromous salmonids (*i.e*, Sacramento winter-run Chinook, CV spring-run Chinook and CCV steelhead) all individuals must travel through the estuary to access the ocean as smolts and return as adults to their natal streams Non-smolting juvenile salmonids are extremely unlikely to be present in the action area due to their life cycle stage need for freshwater.

To assess the potential exposure of threatened green sturgeon and listed anadromous salmonids to dredging and disposal activities, we relied mainly on Hearn *et al's*. 2-year study with ultrasonic tags on fish (Hearn *et al*. 2010). In 2009 and 2010, the study placed tags on 500 Chinook salmon smolts, 500 steelhead smolts and adult green sturgeon tagged in previous studies were also utilized. Approximately 150 tag receivers were deployed at 24 sites throughout Suisun, San Pablo and Central San Francisco bays. Receiver sites included dredging locations, dredged material disposal sites, bridges, as well as shallow bay margin areas and deep water channels. Underwater ultrasonic receivers were also placed at nine marinas in the estuary (Martinez Marina, Vallejo Marina, Port Sonoma Marina, Berkeley Marina, Richmond Marina, Emeryville Marina, San Rafael Canal, Larkspur Ferry Terminal, and Suisun City Marina). The results provided information regarding (1) transit times through various reaches of the estuary; (2) occurrence and duration (*i.e*, "exposure") at various sites; and (3) pathways of downstream migrating smolts.

Results for salmonid smolts showed: (1) the overall transit time from the Benicia Bridge to the Golden Gate was normally less than six days (median 2.7 days); (2) exposure at dredge and disposal sites was variable – most fish were present for less than 30 minutes, but a significant number were detected from 1-20 hours; (3) over 80% of the Chinook salmon smolts were detected at either a dredge or disposal site; and (4) 77% of the steelhead smolts were detected at either a dredge or disposal site. Although the numbers were relatively small, Chinook or steelhead smolts were detected in 2009 or 2010 at the Larkspur Ferry Terminal, Port Sonoma Marina, Richmond Marina, Vallejo Marina, Martinez Marina, and Emeryville Marina. No tagged smolts were detected over the 2-year study in the San Rafael Canal, Berkeley Marina, or Suisun City Marina. Based on these results, Hearn *et al.* (2010) concluded that salmonid smolts did not reside at any of the sites within the estuary, rather they are "exposed" to dredge or disposal sites for some duration of time as they migrate through on their way to the ocean. This work confirmed that salmon and steelhead smolts are widely distributed throughout the San Francisco Estuary during their seaward migration; although their exposure times at the various dredge and disposal sites are relatively short (typically measured in minutes).

Hearn *et al.* (2010) also reports that 47 tagged adult green sturgeon were detected during the study period. Tagged green sturgeon were present in all sections of brackish water from the Golden Gate to Freeport throughout the year; although in greater numbers during the fall and winter period. The highest number of green sturgeon detections was in San Pablo Bay. With the exception of the Martinez Marina, green sturgeon were only briefly detected at the Richmond Marina and Vallejo Marina, and not detected in any of the other marina areas. Although green sturgeon were detected at both the Alcatraz (SF-11) and Carquinez Strait (SF-9) disposal sites, the medium exposure time was under 20 minutes. Green sturgeon presence at the San Pablo Bay disposal site (SF-10) was significantly greater and exposure times ranged from 5 minutes to 19.4 hours (Hearn *et al.* 2010).

2.4.2 Effects of Dredging and Disposal on Listed Fish

The potential impacts to estuarine and marine habitats from dredging and disposal activities conduct under the LTMS Program generally fall into three categories: (1) temporary degradation of water quality; (2) entrainment of aquatic organisms; and (3) periodic disturbance of fish and habitat. Permanent loss of habitat occurred when the action area's 11 federal navigation channels were initially established and dredged (see Table 2). Similarly, permanent habitat losses occurred at marinas, ports, wharfs, and docks when those facilities were initially constructed (see Table 3). Maintenance activities proposed under the LTMS Program will not result in permanent habitat loss in new areas, but it will continue to maintain existing disturbed areas in a degraded condition.

2.4.2.1 Water Quality (Contaminants and Suspended Sediment)

Dredging and in-bay disposal typically creates a sediment plume which degrades water quality in the immediate vicinity of the activity. Mechanical dredging (i.e., clamshell, excavator, environmental bucket) generates more suspended sediments throughout the water column than hydraulic dredges (Barnard 1978). Bottom sediments become suspended as the bucket contacts the bottom and when material washes from top and sides of the bucket as it passes up through the water column. Additional sediment is introduced into the water column as the bucket breaks the water surface, spillage of materials during barge loading, and intentional overflow of water from the barge in an attempt to increase the barge's effective load (Nightingale and Simenstad 2001).

Suction dredges operate a system of pipes and centrifugal pumps to produce a vacuum at the intake and atmospheric pressure forces water and sediments into the suction pipe. Since water and excavated sediments are collected by the pipe, suction dredges create significantly lower levels of suspended materials than mechanical dredging in the water column at the intake location. For disposal of dredged materials, suction dredges typically transport a slurry of sediments via by pipeline to an upland or beneficial reuse disposal site. Upland and beneficial reuse disposal sites are typically isolated from the waters of the San Francisco Estuary by levees, berms and other features; thus, no impacts to water quality in the presence of listed salmonids or sturgeon are anticipated with this type of disposal operation. However, in the hold of a hopper dredge, overflow of excess water poses a risk of increased turbidity as the suspended sediments are released into surrounding waters with overflow water. Hopper dredges may also dispose of dredged materials at an in-water disposal site by opening large doors at the bottom of the dredge.

Aquatic disposal via hopper dredge door opening is proposed at four in-bay locations, two nearshore locations, and one offshore location by the LTMS Program. With the exception the Ocean Beach Demonstration site, all the LTMS aquatic disposal sites are dispersive in that the material is expected to be dispersed either during placement or eroded from the bottom over time and transported away from the disposal site by currents. Aquatic disposal typically creates a sediment plume upon the release of dredged material and the physical behavior of the sediment plume is dependent on the nature of the dredged materials and the hydrodynamics of the disposal site.

The LTMS Program's DMMO process requires sediment testing prior to dredging episodes for the purpose of determining potential contaminant levels in dredged materials and selection of appropriate disposal sites. Based on sediment test results, the DMMO may impose measures at the dredge site as well as restrict disposal placement locations. This DMMO process is expected to continue to minimize the potential for water quality degradation and release of hazardous materials into the water column during maintenance dredging and aquatic disposal events. However, there may be impacts to listed species as described below.

2.4.2.1.1 Contaminants

Toxic metals and organics, pathogens, and viruses, absorbed or adsorbed to fine-grained particulates in the sediment, may become biologically available to aquatic organisms either in the water column or through food chain processes during dredging and aquatic disposal operations. Removal of surface sediments during dredging can also expose a new sediment layer which is more highly contaminated than previous surface sediments. The potential short-term effects of degraded water quality on fish include acute toxicity, subacute toxicity, and biological and other indirect effects such as avoidance (Jabusch *et al*. 2008). Potential long-term effects are associated with bioaccumulation of contaminants. Due to the year-round residency of juveniles in San Francisco Bay and their long life span, green sturgeon are subject to a higher risk of exposure and potential bioaccumulation. Due to their short period of residency in the action area, listed salmonids are significantly less vulnerable to impacts associated with contaminants released by dredging and disposal activities.

Dredged materials distributed throughout the water column can change the chemistry and the physical characteristics of the receiving water by introducing chemical constituents in suspended or dissolved form. Heavy metals (Cd, Cu, Hg, Ni, Pb, Zn, Ag, Cr, As), and organic contaminants (PAHs, PCBs, pesticides) are of particular concern. Additionally, dredge plumes have the potential to cause short-term changes in dissolved oxygen (DO), pH, hydrogen sulfide (H_2S), and ammonia. The rapid conversion to sulfates and nitrate can lead to drops in DO. The introduction of nutrients or organic material to the water column as a result of the discharge can lead to a high biochemical oxygen demand (BOD), which in turn can also lead to reduced dissolved oxygen, thereby potentially affecting the survival of many aquatic organisms. Increases in nutrients can favor one group of organisms such as polychaetes or algae to the detriment of other types.

Contaminants in an aquatic environment typically become available to fish via gill uptake or ingestion with food. The potential short-term effects of contaminant uptake on fish are primarily a function of the fish species, type of contaminant, its concentration in the sediment, the environmental conditions at the time of dredging (e.g., low oxygen or reducing environments), and the duration of the exposure (Jabusch *et al.* 2008).

To better understand the potential short-term effects of water quality impacts on fish during dredging in San Francisco Bay, the San Francisco Estuary Institute (SFEI) completed a literature review in 2008 for the Corps (Jabusch *et al.* 2008). The goal of the literature review was to synthesize and summarize knowledge of short-term water quality impacts due to dredging and disposal operations. Based on key findings by SFEI's literature review and best available information, the effects of the discharge of dredged materials in the water column during in-bay disposal include the following:

- Short-term changes in DO, pH, H_2S, and ammonia may occur in connection with sediment plumes caused by dredging and disposal activities. DO and pH effects are expected to be minimal in most San Francisco Bay conditions due to the small area affected by the discharge plumes in relation to the large area and water volume at the disposal sites. H_2S could be released from anoxic sediments that, if resuspended, would also cause DO depletion (or hypoxia) and releases of ammonia have the potential to result in toxicity. However, both ammonia and H_2S rapidly convert to less or nontoxic forms in the presence of oxygen (elemental sulfur, sulfates, and/or nitrate). Due to small area affected by the dredge plumes in comparison to the large, well-circulated aquatic area of the disposal sites, adverse effects to fish from short-term changes in DO, pH, H_2S, and ammonia are unlikely.

- In sediments, only a small fraction of the total amount of heavy metals and organic contaminants is dissolved. In case of heavy metals, releases during dredging may be largely due to the resuspension of fine particles from which the contaminants may be desorbed, and in case of organic contaminants, most of the chemical released into the dissolved phase would be expected to be bound to dissolved organic matter. Thus, the concentration of freely dissolved metal ions and organic contaminants that would be released and available for gill uptake by fish is presumably minor.

- Direct short-term effects on sensitive fish by contaminants associated with dredging plumes are probably fairly minor, especially in comparison with other potential impacts, such as the immediate physical effects of suspended solids on fish health.

- Long-term adverse effects on fish may occur from bioaccumulation of pollutants such as chlorinated hydrocarbons (e.g., PCBs, DDTs, dieldrin, chlordane, dioxins/furans), mercury, and many PAHs which are known contaminants present in sediments in San Francisco Bay. However, the DMMO process for evaluation of projects prior to dredging includes sediment bioaccumulation testing (see Section 1.3.1 of this Opinion). If contaminant levels in sediments exceed established thresholds, the materials are not disposed at in-bay aquatic sites. If residual layer contamination that would be exposed after maintenance dredging is greater than that in the overlying sediment, and exceeds the bioaccumulation trigger values, the Corps will adhere to a process for case-by-case review as outlined in the *Agreement on Programmatic EFH Conservation Measures for Maintenance Dredging Conducted Under the LTMS Program* (USACE and USEPA, 2011). These measures tie the sediment testing program to San Francisco Bay's existing Total Maximum Daily Loads for mercury and polychlorinated biphenyls, as well as to the established Regional Monitoring Program for San Francisco Bay. In general, the DMMO sediment testing and evaluation procedures for disposal of dredged materials contribute to pollution-reduction in San Francisco Bay.

Based on the above, adverse effects due to contaminants released by dredging and aquatic disposal activities conducted under the LTMS Program are unlikely on listed anadromous salmonids and green sturgeon. This is due to: 1) the small area affected by the discharge plumes in relation to the large area, 2) water volume and tidal circulation at the disposal sites, and 3) sediment testing and evaluation which ensures no in-Bay disposal of sediments that exceed bioaccumulation trigger values and which show bioaccumulation during testing. These factors either minimizes or avoid the chance of exposure and dilute toxic materials to such small amounts that even if exposure were to occur, effects to listed salmonids or green sturgeon would be insignificant.

2.4.2.1.2 Suspended Sediment Levels and Gill Injury

Turbidity is a natural characteristic of estuarine habitats and ambient levels of suspended sediment in San Francisco Bay typically range from ambient turbidity levels generally range from 17 to 290 mg/l (Rich 2011). Following large storms, suspended sediment concentrations may be as high as 300 mg/l (Schoelhammer 1996). During dredging operations, dredge equipment contacting sediments on the bay floor results in the resuspension of sediment into the water column. Aquatic disposal of dredged material also creates a plume of turbidity as sediments disperse and travel downward to the seafloor. The turbidity resulting from dredging and the placement of dredged material may affect aquatic organisms in a variety of ways including: respiration (clogging gills); reduced visibility for foraging; reduced ability to avoid predators; and altered movement patterns to avoid turbid waters (USACE and Reg. Board 2014). Suspended sediments have been shown to affect fish behavior, including avoidance responses, territoriality, feeding, and homing behavior. Wilber and Clarke (2001) found that suspended sediments result in cough reflexes, changes in swimming activity, and gill flaring. Suspended sediments can have other impacts, including abrasion to the body and gill clogging (Wilber and Clarke 2001). Generally, bottom-dwelling fish species are the most tolerant of suspended solids, and filter feeders are the most sensitive (USACE and Reg. Board 2014)

Studies have shown that exposure to suspended sediments in the water column can cause gill irritation and damage (Cordon and Kelly 1961, Servizi and Martens 1992; Newcombe and MacDonald 1991; Lake and Hinch 1999; Wilber and Clarke 2001). The size and shape of the suspended sediment particles as well as the duration of the exposure can be important factors in assessing the risks (Nightingale and Simenstad 2001). Studies by Birtwell *et al*. (1984) with Artic grayling (*Thymallus acticus*) and similar studies by Lake and Hinch (1999) with coho salmon (*Oncorhynchus kisutch*) both found 20% mortality at a concentration of 100,000 mg/L in natural and angular sediments. In concentrations greater than 4,000 mg/L, fish gills revealed erosion at the end of gill filament tips from both round and angular sediments (Nightingale and Simenstad 2001). Martens and Servizi (1993) found juvenile coho exposed to natural Fraser River suspended sediments for a period of 96 hours at concentrations of 16,000-41,000 mg/L showing an average of 1500 sediment particles lodged into gill epithelia with all such particles being of irregular and angular shapes.

Although these studies clearly show high levels of suspended sediments can result in gill injury and mortality, very few listed salmonids and green sturgeon would be expected to encounter suspended sediment concentrations of this magnitude during the implementation of the LTMS Program. Information regarding suspended sediment concentrations generated during dredging and disposal in San Francisco Bay suggest levels are typically be less than 450 mg/l in the sediment plume. Clark *et al*. (2004) monitored the operation of a 12-cubic yard closed bucket dredge at a channel depth between 12 and 13 meters in the Oakland Harbor with an acoustic doppler profiler and water samples. His results showed that suspended sediment concentrations as high as 275 mg/l can occur in the immediately proximity of the dredge and levels above ambient concentrations may be observed as far as 400 meters from the source. In general, Clark *et al.* (2004) reports that total suspended sediment concentrations decayed within short distances from the source.

Rich (2011) reports the results of suspended sediment monitoring at several locations: dredging activities in San Pablo Bay generated suspended sediment levels ranging from 20.3 to 251 mg/l; dredging in Oakland Outer Harbor generated suspended sediment concentrations ranging from 25 to 125 mg/l; dredged material disposal at Alcatraz generated concentrations ranging from 10 to 290 mg/l; and knockdown operations at the Port of Redwood City generated concentrations ranging from 25 to over 450 mg/l. Corps studies of turbidity plumes at aquatic disposal sites has showed that turbidity levels generally return to ambient levels within 20 minutes (USACE and Reg. Board 2014). However, NMFS could find no estimates of suspended sediment concentrations at the point of discharge and levels are likely considerably higher directly beneath the doors at the bottom of a barge or hopper dredge during a disposal event.

Although information regarding direct effects is sparse, a few general conclusions can be drawn regarding the potential effects of suspended sediment concentrations during dredging on listed anadromous salmonids and green sturgeon. Bottom-dwelling (i.e., demersal) fish appear to have more tolerance for high suspended sediment levels than pelagic and or filter feeders (Rich 2011); thus, green sturgeon are likely to be less vulnerable to injury and mortality associated with elevated levels of suspended sediment. Anadromous salmonids are generally more sensitive to suspended sediment and turbidity; thus they are at greater risk of injury and mortality (Rich 2010). Suspended sediment concentrations that would typically be associated with dredging activities are considerably lower than those associated with levels that cause gill injury and mortality. Thus, no injury or mortality of listed salmonids or green sturgeon at dredging sites due to elevated levels of suspended sediment are anticipated during implementation of the LTMS Program. Behavioral impacts due to elevated suspended sediment levels at dredging sites are discussed below in Section 2.4.2.3.

In contrast to dredging locations, in-water disposal of dredged materials are expected to generate very high concentrations of suspended sediments for several minutes within a small area at the point of discharge (i.e., directly beneath the drop doors of a hopper dredge or barge). During an investigation of fish response to a dredged material disposal event at Alcatraz (SF-11), Burcyznski (1991) reports hydroacoustic survey techniques show a very dense sediment plume at the moment of discharge and the plume slowly sinks towards the bottom. If present at the site of release during the actual disposal event, green sturgeon and listed anadromous salmonids could be exposed to injurious or lethal levels of suspended sediment. Individual fish within the water column and directly underneath a hopper dredge or barge during the discharge event will be subjected to very high concentrations of suspended sediment. Concentrations may be at levels that result in injury and mortality due to gill injury, gill clogging, and body abrasion. Although the exact number of listed salmonids and green sturgeon exposed to these very high concentrations of suspended sediment cannot be determined with available information, NMFS expects it to be a very small number and only some of these individuals would be injured or killed on an annual basis. To be subject to injury or morality, an individual listed salmonid or sturgeon will need to present in the water column immediately under the doors of a hopper dredge or barge at the moment of discharge. Dredged material is expected to rapidly disperse as it travels 30+ feet from the water surface to the bay floor at disposal sites; accordingly concentrations of suspended sediment are expected to rapidly lessen with distance from the point of discharge.

As a pelagic species, listed anadromous salmonids commonly occur in the upper portion of the water column and they may be present at an in-bay disposal site during a dredged material placement event. However, the LTMS Program's in-water work window restricts most dredging and disposal activities to the period of June 1 through November 30. Since most disposal events will not occur during the migration season of listed anadromous salmonids, this measure is expected to significantly reduce this source of potential injury and mortality for listed salmonids. However, on an annual basis up to 50,000 cubic yards of material (i.e., 3 to 5% of the annual in-bay disposal volume) may be placed at an aquatic in-bay disposal site and some larger projects also can utilizing in-bay disposal sites outside the work window if they mitigate in the future by placement of a like volume of material at beneficial reuse site during the work window. This in-water disposal of dredged material during the period from December 1 through May 31 at the four in-bay sites is anticipated to result in the loss of a likely very small number of listed adult and smolt anadromous salmonids. Because of the restrictions on in-bay disposal, NMFS anticipates that in some years no salmonids will be injured or killed and those that are in other years will constitute a very, very small fraction of the number of these fish that migrate through the Bay, given the very small size (a few hundred square feet) and short duration (minutes) of high levels of suspended sediment in the disposal release compared to the size of the migration corridor (miles) and duration of migration period (months) in the bay.

Although green sturgeon are year-round residents within the San Francisco Estuary, this species is less likely to be injured or killed by high concentrations of suspended sediment during a disposal event. This is based on green sturgeon's higher tolerance of suspended sediment and water depths at the four in-bay disposal sites. Kelly *et al*. (2007) reports that green sturgeon are typically found in water depths less than 30 feet in depth. With the exception of a small portion of the Carquinez Strait disposal site (SF-9), the four San Francisco Bay aquatic disposal sites are greater than 30 feet in depth. As a demersal fish and preference for swimming along the bottoms of bays and estuaries at depths of less than 30 feet, green sturgeon would not typically be found at the LTMS in-bay disposal sites. However, there is a low risk that an individual green sturgeon could be within the water column and directly underneath a hopper dredge or barge during a disposal event. Green sturgeon have been observed swimming higher in the water column when transiting to other shallow locations in San Francisco Bay (i.e., directional movements) (Kelly *et al*. 2007). As with anadromous salmonids, the short-term and localized very high concentration of suspended sediments during a disposal event may result in injury or mortality of a small number of green sturgeon due to gill injury, gill clogging, or body abrasion. Although losses of threatened green sturgeon are anticipated during in-bay disposal events, NMFS expects the number will be very small. Due to their higher tolerance for suspended sediment and preference for shallow areas, NMFS believes fewer green sturgeon than salmonids will be lost during in-Bay dredging disposal events.

At the two nearshore aquatic disposal sites, green sturgeon and listed anadromous salmonids are unlikely to be adverse affected by disposal events because dredged material discharge at these sites is limited to sand. Due to the particle size and density of sand grains, suspended sediment levels are expected to be low and not result in concentrations that would injury or killed listed salmonids or green sturgeon. At the ocean disposal site, SF-DODS, green sturgeon and listed anadromous salmonids are unlikely to be present because the site is located beyond the continental shelf in waters between 8-10,000 feet in depth. As with the nearshore disposal sites, green sturgeon and listed anadromous salmonids are unlikely to be adverse affected by disposal events at SFDODS.

2.4.2.2 Entrainment

Reine and Clark (1998) define entrainment by hydraulic dredges as direct uptake of aquatic organisms by suction field at the draghead or cutterhead. In addition to hydraulic dredges, entrainment of aquatic organisms is possible with a mechanical dredge. As the bucket of a mechanical dredge collects material from the bottom, aquatic organism can be physically collected with the sediment material. Due to their sedentary behavior, benthic organisms are particularly vulnerable to entrainment by dredges. Demersal and epibenthic organism are also particularly susceptible to entrainment due to their behavior of residing or burrowing into bottom substrates. Other factors influencing the vulnerability of a species to entrainment include reaction time, swimming capability (*i.e.*, speed), and flight response. In general, smaller fish and young life stages have poorer swimming capabilities and, thus, are more vulnerable to entrainment by a dredge. As fish grow and mature, their swimming abilities improve and presumably their ability to avoid entrainment increases.

Although entrainment of fishes has been a concern linked to hydraulic dredging for several decades (Reine and Clarke 1998), information regarding entrainment rates of fish by dredging equipment along the Pacific Coast is limited. The following is a brief summary of fish entrainment studies at hydraulic dredging operations. No information regarding entrainment rates of fish by mechanical dredges was located by NMFS.

McGraw and Armstrong (1990) collected entrainment information during hydraulic dredging on 28 species over a 10-year period in Grey's Harbor, Washington. Trawl sampling was conducted simultaneously with dredging operations to determine if fish were able to avoid entrainment. Most species (e.g., slender sole, *Lyopsetta exilis*) had relatively low absolute entrainment rates approaching 0.001 fish/cy. Species with the highest entrainment rates during this study were the Pacific sanddab (*Citharichthys sordidus*), Pacific staghorn sculpin (*Leptocottus armatus*), and the Pacific sand lance (*Ammodytes hexapterus*) at 0.076, 0.092 and 0.594 fish/cy, respectively.

Larson and Moehl (1990) studied fish entrainment at hydraulic dredges during a 4-year study at the mouth of the Columbia River in Oregon. Entrainment rates ranged from <0.001 to 0.341 fish/cy for 14 species or taxonomic groups of fishes. The majority of fishes entrained were demersal; however, a few pelagic species were collected, including anchovy, herring, and smelt. Entrainment of anadromous fishes was limited to eulachon (*Thaleichthys pacificus*). Larson and Moehl (1990) concluded that it is unlikely that anadromous fishes are entrained in significant numbers by dredges, at least outside of constricted river areas.

Buell (1992) sampled fish entrained by the hydraulic dredge *R. W. Lofgren* on the Columbia River. He reported that with the exception of white sturgeon (*Acipenser transmontanus*), entrainment involved small numbers of a few fish species. The higher rates of entrainment for white sturgeon were attributed to one location known as the "sturgeon hole", a site with greater than average sturgeon densities. Overall, white sturgeon were entrained at a rate of 0.015 fish per cubic yard of dredging.

Taplin and Hanson (2006) evaluated salmon and steelhead entrainment at a hydraulic suction dredge used for sand mining in the Sacramento-San Joaquin Delta in 2006. Their results suggest that very few juvenile salmon (total of 8 juvenile fall-run Chinook salmon in this study) are entrained and this study was considered to overestimate vulnerability to entrainment due to the selected placement of the dredge head in the water column during sampling.

Woodbury and Swedberg (2008) evaluated fish entrainment rates by a hydraulic dredge with a 10-inch diameter intake at a small marina adjacent to San Pablo Bay over a two-year period between December 2006 and January 2008. Their sampling at the Port Sonoma Marina detected no entrainment of salmon, steelhead or sturgeon. During the first year of the study, some striped bass were entrained, but none were entrained during the second year for the study.

To assess potential entrainment rates of listed fish in the Sacramento-San Joaquin Delta, Mari-Gold Environmental Consulting and Novo Aquatic Sciences (2010) performed four years of fish community monitoring and five years of dredge entrainment monitoring in two deep water ship channels regularly dredged by the Corps (*i.e.,* Stockton Deepwater Ship Channel and the Sacramento River Deepwater Ship Channel). During the 5-year study period, 33 native and non-native fish species were encountered and the majority of the entrained species were demersal. No listed fish species were detected in the entrainment samples. Fish community monitoring did detect listed fish species within the dredging reach, although in relatively low numbers (Mari-Gold Environmental Consulting and Novo Aquatic Sciences 2010). Due in part to the low abundance of listed fish species, Mari-Gold Environmental Consulting and Novo Aquatic Sciences (2010) concluded rarity in the environment also decreases potential for entrainment.

Some dredge sites within the LTMS Program area are located at the mouths of known steelhead streams, specifically the Napa River/Mare Island Strait, Petaluma River, Larkspur/Corte Madera Creek, and Novato Creek. At these sites, the dredging occurs at the transition from open bay waters to the more confined channel of these tributary streams. As steelhead adults return to their natal streams in the winter months and steelhead smolts depart their natal streams in the late winter and spring, greater densities of individuals due to more constricted channels significantly increase the risk of entrainment during dredging. The superior swimming capabilities of adult steelhead likely allow them to avoid entrainment at the intake of a hydraulic dredge; however, downstream migrating smolts typically range from 150 to 250 mm in size and may be overcome by the intake velocities of a large hydraulic dredge. For this reason, the LTMS Program work windows are in place for all planned projects. Unplanned projects with unavoidable needs to complete a portion of their ongoing dredging outside the work window may be permitted by the LTMS agencies (i.e., Corps) at these locations near the mouth of steelhead streams, but NMFS expects these events would occur in December immediately following the closure of the work window on November 30. Since the cumulative allocation for extension of ongoing dredge projects into the work window is limited to 50,000 cubic yards of materials per year, dredging extensions are anticipated to be completed in December and no dredging activities are expected to continue at the mouths of steelhead streams during the peak smolt outmigration period in March, April and early May.

Based on the best available information, the entrainment of listed anadromous salmonids during dredging under the LTMS Program is expected to be very low for the following reasons. First, the San Francisco Estuary includes extensive areas of open water which allow fish to disperse over a greater area as they migrate through the estuary. Due to their low abundances, the potential for occurrence of listed fish species at an active dredge site is low. Second, anadromous salmonids are less likely to encounter the intake of a hydraulic dredge operating on the bay bottom because they are a pelagic species. The LTMS Program has established a best management practice that requires hydraulic pumps on suction dredges to only be turned on when the intake is on or within 3 feet of the seafloor. By avoiding the operation of a hydraulic intake in the upper and middle portion of the water column, listed salmonids are unlikely to encounter an operating intake near/on the seafloor. Third, the LTMS Program work windows are designed for most dredging projects to be conducted from June 1 through November 30 when few adult and juvenile listed salmonids are expected to be migrating through the San Francisco Estuary.

As a demersal species, green sturgeon would potentially be more vulnerable to entrainment during dredging; however, available information suggests the potential for green sturgeon entrainment by a suction dredge is low. Five years of entrainment sampling by Mari-Gold Environmental Consulting and Novo Aquatic Sciences (2010) in the Sacramento-San Joaquin Delta did not observed entrainment of any sturgeon, including the more common white sturgeon. All green sturgeon in the San Francisco Estuary are also relatively large in size (i.e., typically 18 inches in length or greater). Larger fish have stronger swimming capabilities and, thus, are less vulnerable to entrainment.

Given the ability of salmonids and green sturgeon to detect noise, turbidity, water velocities and other environmental cues, their own stimuli likely provides an effective protection against entrainment during dredging. Although some entrainment losses of juvenile listed anadromous salmonids and juvenile green sturgeon are anticipated, the number is expected to be very low and information is not available to precisely quantify the number of fish entrained during LTMS Program hydraulic dredging. Due to their larger body size and stronger swimming ability, no adult listed salmonids nor adult green sturgeon are expected to be entrained during dredging.

2.4.2.3 Behavior

Several researchers have assessed the behavioral effects of dredging on fish. Carlson *et al.* (2001) evaluated the effects of dredging activities in the lower Columbia River with hydroacoustic observations of anadromous salmonids. This research was conducted over a three-year period from 1995 through 1998 and documented several behavioral responses by downstream migrating juvenile salmonids to dredging and dredged material plumes. Responses were summarized as (a) fish that were oriented along the deep channel margin moved inshore when encountering a dredge; (b) most fish passing inshore moved offshore when encountering a dredge; and (c) fish assumed normal patterns shortly after encountering dredge and dredge plumes.

The sediment plume resulting from dredging and disposal will likely affect the behavior of listed anadromous salmonids and green sturgeon in several ways. Available information suggests pelagic fish, (including salmonids) demonstrate avoidance behaviors to dredging and dredge plumes, while epibenthic and sedentary species (including sturgeon) may be more neutral in their response. Laboratory tests performed by Gregory and Northcote (1993) exposed juvenile Chinook salmon to turbidity levels ranging from 1 to 810 NTUs, and they found that feeding rates were greatest at NTU levels ranging from 35 to 150 NTUs. Gregory (1993) also concluded that exposure to turbid water reduced the predator-avoidance recovery time for juvenile Chinook salmon.

In contrast to Gregory and Northcote (1993), Madej *et al*. (2007) found that juvenile steelhead and coho salmon had reduced feeding activity at relatively low turbidity levels of 25-45 NTUs. Reduced reactive distance to increasing turbidity levels from 17 to 63 NTUs was identified by DeYoung (2007). Bisson and Bilby (1982) detected avoidance response by coho salmon at turbidity levels of 70 NTUs. Sigler *et al*. (1984) examined steelhead and coho salmon fry and juvenile behavior in experimental channels and found fish emigrated from channels with higher sediment loads (100 to 300 NTUs). When fish were retained in channels with high turbidity, Sigler *et al*. (1984) concluded growth rates were significantly higher in clearer water channels when compared to turbid water channels.

Adult and smolt listed anadromous salmonids are expected to generally avoid sediment plumes associated with dredging when clearer open water areas are available adjacent to the plume. Green sturgeon are tolerant of high levels of suspended sediment and are less likely to be disturbed by the sediment plume associated with dredging activities. Because of their foraging behavior which exposes them to sediments and turbidity, green sturgeon may not react to higher levels of turbidity. Green sturgeon may not alter their direction of travel or other behaviors if they encounter turbidity and because of this lack of response, and their higher tolerance of turbidity (as evidenced by their foraging behavior) are unlikely to be adversely affected by the short term turbidity plumes generated by dredging and disposal. The expanse of open waters throughout the San Francisco Estuary are expected to provide ample opportunity for listed fish to avoid the immediately vicinity of an operating dredge and its associated sediment plume. Similarly, sediment plumes associated with dredging are not expected to result in reduced visibility for foraging or reduced ability to avoid predators because the plumes are temporary, localized, and fish will have the ability to avoid overlap with the area of elevated turbidity. Nightingale and Simenstad (1991) concluded that the primary determinant of risk level associated with behavioral effects on migrating fish lie in the spatial and temporal overlap with the area of turbidity, the degree of turbidity, the occurrence of fish, and the options available for fish to access open waters.

The upstream and downstream passage of listed fish through the San Francisco Estuary is not anticipated to be adversely affected by dredging and disposal activities. As stated above, most dredging and in-water disposal will be restricted to the period between June 1 and November 30 when few listed salmonids are expected to be migrating through San Francisco Bay. Additionally, it is anticipated that areas adjacent to active dredge sites will be available and provide for the migration of listed salmonids and green sturgeon. Findings presented by Carlson *et al*. (2001), Bisson and Bilby (1982), and Sigler *et a*l. (1984) indicate that juvenile salmonid migration behavior may be disrupted through an avoidance response when encountering dredging activity or a disposal-generated sediment plume, but migration behavior is expected to return to normal soon after encountering a dredge or dredge plume. Burczynski (1991) utilized hydroacoustic survey techniques to assess the behavioral response of fish to a dredged material disposal event at Alcatraz (SF-11) and concluded that fish tend to exhibit avoidance behavior for about two to three hours after dredged material placement. Burcyznski (1991) concluded fish community densities generally return to pre-disposal levels after about three hours. Thus, fish migration could be disrupted for a period of two to three hours; however, it is more likely that migrating fish will utilize portions of bay channels adjacent to active dredge sites that are unaffected by the dredging or disposal activity. Listed anadromous salmonids and green sturgeon are expected to successfully transit the Bay via routes around dredging/disposal sites and little to no delays or impediments to migration would occur. Based on the best available information, the most significant potential effect of dredging on the migration of listed anadromous salmonids or green sturgeon would be a delay of two to three hours, or a detour around the sediment plume. In both cases, the migration of listed salmonids and sturgeon is expected to be unimpaired by dredging and disposal activities conducted under the LTMS Program.

2.4.2.4 Noise

Underwater sound exposures are known to alter the behavior of fishes (see review by Hastings and Popper 2005) and extremely high levels can result in physical injury or mortality. Fish use their hearing abilities and sound to detect predators, locate prey and interact socially. Underwater noise generated by dredging activities originates primarily from the operation of the bucket or hydraulic intake and sounds generated by the engine and propeller of the vessel. Cargo ships and tug boats in San Francisco Bay have been estimated to generate sound levels ranging from 135 to 145 dB (re: 1 μPa) at a distance of 600 feet while background noise levels for the bay are estimated to range from 110 dB in quiet shallower areas to 125 dB in main shipping channels (J. Reyff, Illingworth and Rodkin, personal communication 2008).

Field studies by Clarke *et al*. (2003) and Dickerson *et al*. (2001) characterized underwater sounds produced by three common dredge types (bucket, hydraulic cutterhead, and hopper). Sources of underwater noise generated by dredging activities include both continuous (e.g., propellers, pumps, and generators) and repetitive sounds (e.g., the dredge bucket striking the channel bottom). Bucket dredges have a repetitive sequence of sounds generated by winches, bucket impact with the substrate, closing and opening of the bucket, and sounds associated with dumping of material into the barge. Cutterhead dredges have relatively continuous sounds made by the cutterhead rotating through the substrate. The studies of Clarke *et al*. (2003) and Dickerson *et al*. (2001) found that cutterhead dredging operations were relatively quiet compared to other sound sources in aquatic environments. Hopper dredges produce a combination of sounds from the engine and propeller, that are similar to those from large commercial vessels, and sounds of the draghead moving in contact with the substrate.

Fish may be injured or killed when exposed to very high levels of underwater sound, especially those generated by impulsive sound sources such as pile driving with impact hammers. Noise levels generated by LTMS Program dredging and disposal activities are not expected to rise to levels that result in hearing loss, physical injury, or mortality of listed fish. However, sound levels may be high enough above ambient levels to alter the behavior of fish in the vicinity of an active dredge operation. Behavioral changes would likely include startle responses and avoidance of the immediately area of dredging activity. Exposure to elevated underwater sound levels may also result in "agitation" of fishes indicated by a change in swimming behavior as detected by Shin (1995), or "alarm" detected by Fewtrell (2003). Other potential changes include reduced predator awareness and reduced feeding. The potential for behavioral effects varies by species and depends on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected by underwater sound.

A study in Puget Sound, Washington suggests that noise created by pile driving operations disrupt juvenile pink and chum salmon (*Oncorhynchus spp.*) behavior (Feist *et al*. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. Based on these observations, an active dredge operation may disrupt normal foraging, schooling, and migratory behaviors of juvenile anadromous salmonids. Similar behavior may be exhibited by threatened green sturgeon in response to noise generated by dredging activities.

Assuming the worst case scenario, elevated sound levels due to an active dredge operation would result in the departure of listed salmonids and green sturgeon from the immediate vicinity of the activity. Due to the relatively high ambient underwater noise levels in San Francisco Bay at marinas, wharfs, shipping channels and ports, the area of elevated underwater sound around an operating dredge is expected to be limited to a few hundred feet[5], but empirical data is lacking to adequately characterize sound emitted during dredging. If noise levels result in listed fish vacating the site of an active dredge operation, dredging will temporarily reduce the amount of available foraging habitat. As the dredging operation sequentially moves through the channel, marina, or dock dredging area, listed fish will be able to resume use of the area. Based on the number of acres of aquatic habitat in San Francisco, San Pablo and Suisun bays, the small size of the zone of behavioral effects at an active dredge operation, and the temporary nature of the noise from dredging activities, the fitness of individual salmonids or green sturgeon is unlikely to be reduced. Fish that move because of noise from dredging are expected to quickly find areas adjacent to dredging sites with habitat of similar or higher quality, because dredging will be

[5] Beyond this distance noise from the proposed action would likely reduce to ambient background levels.

conducted around and beneath existing wharfs, docks, and piers, and within existing marinas and navigation channels. These areas are generally degraded by regular maritime activities including vessel traffic and previous dredging episodes; thus, adjacent areas that have been subject to less human-related disturbance are likely providing higher value foraging habitat for listed fish.

In summary, available information indicates elevated noise associated with operation of dredging and disposal equipment will not result in physiological adverse effects to listed fish. However, behavioral changes would likely include startle responses and avoidance of areas with operating dredge equipment. These behavioral effects are expected to be temporary and not adversely affect the fitness of listed salmonids or green sturgeon.

2.4.3 Effects on Designated Critical Habitat

Designated critical habitat for Southern DPS green sturgeon, CCC steelhead, and Sacramento River winter-run Chinook salmon occurs in the action area. Dredging and disposal activities may impact designated critical habitat for these species by altering water quality and foraging habitat PCEs within CCC steelhead critical habitat; water quality and foraging habitat physical and biological features for Sacramento River winter-run Chinook salmon critical habitat; and water quality, foraging habitat, and sediment quality PCEs within green sturgeon designated critical habitat.

Water Quality. The effects of dredging and disposal on water quality were discussed above in section 2.4.2.1 of this biological opinion and also apply to the critical habitat within the action area. As described above, the effects of the proposed project may result in increased levels of turbidity and the re-suspension of sediment-associated contaminants. NMFS does not expect the impacts on water quality will adversely affect PCEs or physical and biological features of Chinook salmon, steelhead, or green sturgeon because contaminants within the action area are not found at concentrations harmful to these species. Increases in turbidity levels will be temporary and water quality is expected to improve within 2-3 hours following individual dredging and disposal events.

Foraging Habitat. Dredging results in the removal of the top layer soft or sandy bottom habitat and removal of invertebrate prey species in that layer. Empirical research suggests that even in dynamic environments, anthropogenic disturbance to the biological community, combined with the physical alteration of habitat, results in a loss of ecological function over varying timescales (Oliver *et al*. 1977; Reish 1961; Thrush *et al*. 1995; Watling *et al*. 2001). Recovery of the disturbed habitat could take months to years (Gilkinson *et al*. 2005), or never return its pre-disturbed state (McConnaughey *et al*. 2000). Recovery time depends on the frequency of disturbance, sediment characteristics, and the level of environmental disturbance by waves and currents at the site.

Direct removal of prey resources (e.g., entrained with bottom sediments) during dredging has the potential to reduce the amount of preferred forage species at the dredge site and may also facilitate the establishment of invasive species to disturbed areas. At disposal sites, the placement of dredged material may result in the burial of fish forage species. Information on juvenile salmonid and green sturgeon foraging behavior in the bay is limited. As described in Section 2.3.2 of this Biological Opinion, research indicates that most juvenile salmonids use the estuary only during outmigration, and pass through the estuary rapidly. Subyearling Chinook are more likely to rear in the estuary than other species and life histories of salmonids. These fish appear to prefer shallow water habitats near the shore and within the upper portion of the water column (less than 10 feet deep) (Kjelson *et al*. 1982). Areas typically dredged for maintenance of the federal navigation channels and areas dredged at docks, wharfs and marinas are generally highly disturbed sites with degraded habitat values. Due to urbanization, highly modified shorelines and the presence of maritime facilities and activities, these dredge locations provide lower habitat values and reduced prey availability. The propeller wash of vessel traffic can disrupt the establishment of a stable benthic community in these areas. The proposed continuation of maintenance dredging at shallow water sites like marinas will not expand the footprint of disturbed area, but it will continue to subject these sites to periodic disturbance and maintain the existing degraded condition. Based on this information, NMFS concludes that dredging and disposal conducted under the LTMS Program will adversely affect salmonid critical habitat by continuing to preclude improvement in the quality of foraging habitat PCE within the action area.

At the LTMS in-water disposal sites, benthic organisms which may serve as prey for listed salmonids are buried by the periodic placement of dredged materials; however, the LTMS Program disposal sites are located in waters greater than 30 feet deep in San Francisco Bay and listed salmonids are not known to forage for prey at these depths. Therefore, impacts on salmonid prey species from dredging and disposal are likely minimal and NMFS does not expect PCEs or physical and biological features related to forage for listed Chinook salmon and steelhead will be adversely affected.

Little is known about green sturgeon feeding and prey resources in estuarine waters, but it is likely that they prey on demersal fish (e.g., sand lance) and benthic invertebrates similar to those that green sturgeon are known to prey upon in estuaries of Washington and Oregon (Dumbauld *et al*. 2008). Research indicates that San Francisco Bay is an important area for juvenile green sturgeon rearing and residence, although, the distribution of green sturgeon and their movements in the bay are not well known. Green sturgeon are known to be generalist feeders and may feed opportunistically on a variety of benthic species encountered. For example, the invasive overbite clam, *C. amurensis*, has become the most common food of white sturgeon, and for the green sturgeon that have been examined to date (CDFG 2002). Sub-adult and non-spawning adult green sturgeon reside in San Francisco Bay during the summer months. Recent results of acoustic tagging studies suggest this period of residence is typically 6 weeks (UC Davis 2014).

The periodic disturbance created by dredging activities may facilitate the establishment of invasive species, such as the overbite clam, in dredged areas and elsewhere in the bay. The act of removing mud and sandy-bottom habitat and the associated biotic assemblages during dredging creates an area of disturbance that is susceptible to recolonization by invasive species, often resulting in the displacement of native species. As a result, dredging may result in the increased distribution and abundance of invasive species in these areas, which in turn would reduce the amount of native prey resources available to green sturgeon at dredge sites.

While effects on benthic habitats and prey resources for green sturgeon are unclear, due to several factors NMFS does not expect dredging and dredged material disposal by the LTMS Program will prevent sturgeon from finding suitable forage at the quantities and quality necessary for normal behavior (e.g., maintenance, growth, reproduction). First, green sturgeon are generalist feeders and the reduction of certain prey species by dredging within navigation channels, marinas, docks and wharf areas is unlikely to affect availability of prey resources for green sturgeon throughout the bay. Second, while dredging will likely continue to help create conditions suitable for invasive species in the Bay, because invasive species are so ubiquitous in San Francisco Bay, dredging is not expected to result in significant changes to invasive species distributions or abundance. Third, the LTMS Program is limited to maintenance of existing shipping channel, marinas, docks, wharfs and similar man-made facilities. These areas have been modified by previous dredging episodes and maritime development. The proposed continuation of maintenance dredging at these sites will not expand the footprint of disturbed area, but it will continue to subject these sites to periodic disturbance and help maintain the existing degraded condition. Based on this information, NMFS concludes that dredging and disposal conducted under the LTMS Program will adversely affect green sturgeon critical habitat in the action area by continuing to preclude improvement in the quality of PCEs. NMFS notes that PCE quality is severely limited by urbanization and resulting tidal wetland loss in these areas by historic Bay fill practices. While maintenance dredging helps maintain marinas and navigation channels, the added degradation from maintenance dredging at marinas and channels is relatively minor.

Eelgrass (*Zostera marina*) and other species of submerged aquatic vegetation contribute important elements to foraging habitat for listed salmonids and green sturgeon in the San Francisco Estuary. Aquatic vegetation can function as an important structural environment for resident bay and estuarine species, offering refuge from predators and current velocity (Orth 1977, Peterson and Quammen 1982). Juvenile listed salmonids and green sturgeon likely benefit from the physical cover provided by eelgrass and other aquatic vegetation. Beds of submerged vegetation also provide a food source for listed fish because these areas commonly function as a nursery for many finfish and shellfish species (Hoffman 1986, Heck *et al.* 1989, Dean *et al.* 2000, Semmens 2008). Eelgrass beds supply organic material to nearshore environments, and their root systems stabilize area sediments. In San Francisco Bay, eelgrass beds are considered to be valuable shallow water habitat, providing shelter, feeding, or breeding habitat for many species of invertebrates, fishes, and some waterfowl.

Dredging and disposal activities may damage or destroy beds of submerged aquatic vegetation, including eelgrass. Direct removal of eelgrass can occur when eelgrass is growing within the dredge project footprint (Sabol *et al.* 2005). During the 2011 NMFS-Corps programmatic EFH consultation for the LTMS, dredge and disposal sites in close proximity to established eelgrass beds were identified. To address potential impacts, the *Agreement on Programmatic EFH Conservation Measures for Maintenance Dredging Conducted Under the LTMS Program*

(USACE and USEPA, 2011) includes conservation and mitigation measures to avoid and minimize adverse effects to eelgrass beds from dredging operations. Eelgrass is likely uncommon within the dredge project footprint of LTMS Program project sites because LTMS activities are limited to maintenance dredging of existing facilities and these areas are unlikely to support eelgrass due to vessel traffic and periodic dredging. Thus, periodic dredging likely keeps eelgrass from expanding into areas of navigation channels and marinas.

Another impact to eelgrass and other species of submerged aquatic vegetation is susceptibility to damage by reduced light or partial burial resulting from the sediment plume during dredging or disposal. The distribution of eelgrass in the San Francisco Estuary is limited by turbidity levels and depth to which light can penetrate at levels high enough to sustain eelgrass growth (USACE and Reg. Board 2014). Sediment plumes generated by dredging and disposal may temporarily reduce the amount of light available to eelgrass and adversely affect the growth and survival of beds. The loss of eelgrass beds could decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, or reduce the density of benthic invertebrates. However, available information regarding dredge sediment plumes suggests impacts to eelgrass beds are unlikely to reach levels that result in the above impacts because dredge project sites are subject to tidal influence and elevated levels of turbidity are expected to be short-term, localized and quickly disperse from the area with tidal circulation. Dredging activities that occur within close proximity to established eelgrass beds in San Francisco Bay utilize minimization measures, such as silt curtains, to minimize and contain plumes of suspended sediments (USACE and USEPA 2011). Dredge disposal sites are located in waters that are too deep to support eelgrass. For these reasons, potential effects to eelgrass and other species of submerged aquatic vegetation is not expected to impair or degrade physical or biological features essential for the conservation of Sacramento River winter-run Chinook salmon or PCEs of designated critical habitat for green sturgeon and CCC steelhead.

Sediment Quality. As described above, research indicates that most juvenile salmonids use the estuary only during outmigration, stay within the upper portion of the watershed (less than 10 feet deep) (Kjelson *et al*. 1982), and pass through the estuary rapidly. Therefore, impacts on sediment quality from dredging and disposal are not expected to adversely affect PCEs of Chinook and steelhead.

Sediment quality PCEs for green sturgeon designated critical habitat consist of suitable chemical characteristics in sediments that are necessary for normal behavior, growth, and viability of all life stages of green sturgeon. The continuation of maintenance dredging by the LTMS Program has the potential to alter the physical, chemical, and biological sediment dynamics within dredged sites and material placement areas in the Bay. The bottom sediments in dredged areas may cause slumping or erosion of adjacent or nearby shallow water habitats through destabilization of channel forms, and may indirectly cause or contribute to erosion of shallow habitats upstream and downstream. By removing bottom material from one place in a system, a chain of transport events could be initiated, which removes sediment from elsewhere, as the local area attempts to reestablish equilibrium. Most areas of dredging disturbance will be replenished with new sediment over time. These physical alterations to benthic substrates could affect the chemical properties of the sediment and the biological communities present. The biological communities in dredging sites are accustomed to a dynamic environment with high velocity currents. However, as described above, even in dynamic environments, the ecological function of these communities may take months to years to recover (Gilkinson *et al*. 2005), or never return its pre-disturbed state (McConnaughey *et al*. 2000).

The association of green sturgeon to deep estuarine benthic habitats is not well understood. Information suggests that green sturgeon primarily aggregate in shallow mud-dominated areas of the estuary, and use deeper channels for migration or rapid movements at the surface (Kelly *et al*. 2007). Based on this information, NMFS assumes that alterations to benthic habitats in deeper navigation channels would not degrade PCEs of green sturgeon critical habitat to the extent that it would not support the normal behavior, growth, and viability of all life stages of green sturgeon in the action area. Marinas, docks and wharf areas are commonly shallow mud-dominate areas, but these sites are typically degraded due to a history of human disturbance, including urbanization and shoreline development, and generally offer lower habitat value to green sturgeon than adjacent undisturbed areas. Continued dredging in and around marinas, wharfs and docks would continue to prevent PCEs of green sturgeon critical habitat from improving in these areas.

2.4.4 Effects of Beneficial Re-use for Wetland Restoration

In addition to the placement of dredged materials at in-bay, nearshore, or ocean disposal sites, dredged materials may be placed at beneficial re-use sites to support the creation of tidal wetlands. Beneficial re-use sites and wetland restoration projects generally require permits from the Corps pursuant to the section 404 of the CWA. NMFS assumes that all upland beneficial re-use sites and tidal wetland restoration projects utilized by the LTMS Program have either completed section 7 consultation with NMFS and the Corps, or will undergo a consultation with NMFS and the Corps prior to the Corps' issuance of a CWA 404 permit.

Planned LTMS dredging projects that are performed outside of the work windows for listed anadromous salmonids (June 1 through November 30) are required by the LTMS Program to placed dredged materials at a beneficial reuse site that will provide future aquatic habitat benefits for San Francisco Bay native species. The placement of dredged materials at tidal wetland restoration sites are generally performed with the use of an offloader. During the offloading of dredged material from barges, water is typically pumped through a screened intake to create a slurry mixture of water and dredged material. The slurry mixture is transported by pipeline to the future wetland restoration site.

Future restoration sites around the margins of San Francisco Estuary are typically isolated from bay waters by perimeter levees. Dredged material placement activities within the existing perimeter levees will not affect ESA-listed fish or habitat, because the project area remains isolated from tidal sloughs and bay waters. Upon completion of construction and dredged material placement, wetland restoration sites will be opened to tidal influence by the breaching of the perimeter levees.

Once completed, tidal wetland restoration sites are expected to benefit listed anadromous salmonids, green sturgeon and designated critical habitat by increasing the amount of tidal marshland around the San Francisco Estuary. Over time, some existing riprap shoreline areas will be replaced by levee breaches in several locations and the restoration of tidal action will create a network of intertidal channels extending into areas now separated from the bay waters by perimeter levees. Breaches are expected to adjust to the new hydrodynamic regime and the wetland areas will mature with marsh vegetation. Restored marsh plain and with tidal channels are anticipated to improve water quality and increase foraging opportunities for green sturgeon and salmonids. For these reasons, the placement of dredged materials at beneficial reuse sites for tidal wetland restoration projects are expected to benefit critical habitat of anadromous salmonids and green sturgeon.

2.5 Cumulative Effects

Cumulative effects are defined in 50 CFR § 402.02 as "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". Many actions occurring in adjacent watersheds may affect the action area of this proposed project. Any future Federal actions will be reviewed through separate section 7 consultation processes and not considered here.

NMFS does not anticipate any cumulative effects in the action area other than those ongoing actions already described in the Environmental Baseline above, and resulting from climate change. Given current baseline conditions and trends, NMFS does not expect to see significant improvement in habitat conditions in the near future due to existing land and water development in San Francisco Bay. In the long term, climate change may produce temperature and precipitation changes that may adversely affect listed anadromous salmonids and green sturgeon habitat in the action area. Freshwater rearing and migratory habitat are most at risk to climate change. However, productivity in the San Francisco Bay is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia *et al*. 2002). This may result in altered trophic level interactions, introduction or survival of invasive species, emergence of harmful algal blooms, changes in timing of ecological events, all of which may cause decreases (or increases) in abundance of green sturgeon and salmonids as well as of their predators and competitors.

2.6 Integration and Synthesis

CCC and CCV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and southern DPS green sturgeon have experienced serious declines in abundance, and long-term population trends suggest a negative growth rate. Human-induced factors have reduced populations and degraded habitat, which in turn has reduced the population's resilience to natural events, such as droughts, floods, and variable ocean conditions. Global climate change presents another real threat to the long-term persistence of the population, especially when combined with the current depressed population status and human caused impacts. Within the project's action area in San Francisco Bay, San Pablo Bay, and Suisun Bay, the effects of shoreline development, industrialization, and urbanization are evident. These activities have introduced non-native species, degraded water quality, contaminated sediment, and altered the hydrology and fish habitat of the action area. As a result, forage species that listed salmonids and green sturgeon depend on have been reduced, and periodic releases of contaminants occur from ships, piers, adjacent land areas, and stormwater runoff.

Future dredging and disposal of dredged materials conducted under the LTMS Program and addressed by this biological opinion must be conducted in compliance with the following programmatic measures:

(1) The work window for dredging and disposal is June 1 through November 30.
(2) No dredging will be permitted from December 1 through May 31 upstream or within 1000 feet bayward of the mouths of Larkspur/Corte Madera Creek, Napa River Channel/Mare Island Strait, Petaluma River, and Novato Creek.
(3) Projects may plan work for the period outside the work window (December 1 through May 31) provided the project mitigates for its impacts by placing dredged material at a beneficial re-use site, such as tidal wetlands restoration site. If a project is unable to place all material dredged outside the work window at a beneficial re-use site, the LTMS Program measures allow for an equivalent volume of dredged material to be placed at a beneficial re-use site from a project conducted within the work windows during the following season. This exemption does not apply to dredge sites upstream or within 1000 feet bayward of the mouths of Larkspur/Corte Madera Creek, Napa River Channel/Mare Island Strait, Petaluma River, and Novato Creek.
(4) Projects that incur an unplanned and unavoidable need to complete a portion of an ongoing dredging operation outside of the work window, the LTMS agencies may approve up to 50,000 cubic yards of dredging and disposal per year for this purpose. This exemption may apply to dredge sites upstream or within 1000 feet bayward of the mouths of Larkspur/Corte Madera Creek, Napa River Channel/Mare Island Strait, Petaluma River, and Novato Creek.

Since dredging and disposal under the LTMS Program could occur at any time of year, CCC and CCV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Southern DPS green sturgeon may be present during LTMS Program activities. Dredging and disposal have the potential to affect listed fish through degradation of water quality, entrainment, and reduction and alteration of foraging habitat. Sediment-associated contaminants re-suspended within dredge sediment plumes are not expected to occur at levels known to cause reductions in fitness to listed fish. At dredge sites, increases in turbidity will be temporary and levels are anticipated to not significantly exceed natural conditions typically encountered by listed fish in the San Francisco Estuary. During disposal events at in-bay aquatic site, suspended sediment concentrations are expected to be very high at the point of discharge and could result in gill injury, gill clogging and body abrasion to fish. Although the likelihood of listed fish presence concurrent with the aquatic discharge of dredged sediments by a barge or hopper dredge is low (see description in section 2.4.2.1), over the remaining 35-year term of LTMS

Program a small number of listed anadromous salmonids and green sturgeon are expected to be injured or killed during in-bay disposal events. As described above in Section 2.4.2.1, NMFS is unable to precisely estimate the number of listed fish expected to be injured or killed by extremely high concentrations of suspended sediment during in-bay disposal events conducted under the LTMS Program.

Hydraulic dredging has the potential to entrain fish and other aquatic organisms in the suction pipe. Best management practices that require pumps to be turned on only when the intake is within three feet of the seafloor are expected to reduce the risk of listed fish from being entrained. However, a small number of listed smolt anadromous salmonids and juvenile green sturgeon may be entrained by hydraulic dredging activities conducted under the LTMS Program. NMFS assumes all fish entrained through a hydraulic dredge will be killed. As described above in Section 2.4.2.2, NMFS is unable to estimate the number of listed fish expected to be entrained during dredging activities conducted under the LTMS Program. However, NMFS expects that the number of listed fish entrained will be very small due to the timing of most dredging activities, the relatively small number of listed fish present when dredging occurs, and the project's minimization measures which reduce the chances that smolts or juvenile green sturgeon will be directly adjacent to suction dredges when these dredges are operating. Due to their larger body size and stronger swimming abilities, no adult listed salmonids nor adult green sturgeon are expected to be entrained during dredging.

Noise and the sediment plume generated by dredging and disposal activities will likely affect the behavior of listed anadromous salmonids and green sturgeon. Available information suggests pelagic fish, (i.e., listed salmonids) demonstrate avoidance behaviors to dredging and dredge plumes, while epibenthic and sedentary species (including sturgeon) may be more neutral in their response. In the San Francisco Estuary, ambient turbidity levels generally range from 10 to 180 NTUs and are primarily influenced by upstream sources of sediment, sediment input during storm events, and wind-inducted wave action. Adult and smolt listed anadromous salmonids are expected to generally avoid sediment plumes associated with dredging when clearer open water areas are available adjacent to the plume. Green sturgeon are tolerant of high levels of suspended sediment and are less likely to be disturbed by the sediment plume associated with dredging activities. Listed fish are unlikely to be adversely affected by the short term turbidity plumes and noise generated by dredging and disposal. The open expanse of waters throughout most of the action area are expected to provide ample opportunity for listed fish to avoid the immediately vicinity of an operating dredge and its associated sediment plume.

Designated critical habitat for Southern DPS green sturgeon, CCC steelhead, and Sacramento River winter-run Chinook salmon occurs in the action area. Dredging and disposal activities may adversely affect designated critical habitat for these species by altering water quality and foraging habitat PCEs within CCC steelhead and Sacramento River winter-run Chinook salmon critical habitat; and water quality, foraging habitat, and sediment quality PCEs within green sturgeon designated critical habitat. Dredging and disposal has occurred within the action area for over 100 years and available information indicates that dredging has temporary impacts on benthic habitat through the direct disturbance of epifauna, infauna, and demersal species. Long-term impacts to benthic and shoreline habitat appear to primarily be related to urbanization and the creation of the facilities that are now subject to periodic maintenance dredging under the LTMS Program. As a modern-day hub of international commerce, urbanization and maritime development are extensive in San Francisco. The filling of wetlands for housing and industries, and the creation of shipping channels, docks, port and wharf facilities has resulted in significant modifications to aquatic habitat and degraded conditions for listed fish and their native prey base. Since dredging occurs repeatedly at navigation channels, marinas, docks and wharfs, the temporary impacts would reoccur over the duration of the LTMS Program, to the extent that they are more appropriately considered chronic impacts. Despite these impacts, the current ecological distribution of listed salmonids and green sturgeon in the Bay suggest that areas subject to maintenance dredging are not of prime importance for foraging and LTMS Program activities will not adversely affect conditions for migration. Adverse effects to critical habitat by the LTMS dredging and disposal activities are not expected to result in an appreciable reduction in critical habitat value at the entire critical habitat designation scale for listed species, due largely to the small amount of critical habitat adversely affected and the remaining critical habitat nearby in San Francisco Bay and elsewhere that is undisturbed by dredging and is generally in much better condition.

Based on the above, a small number of CCC steelhead, CCV steelhead, CV spring-run Chinook, Sacramento River winter-run Chinook, and green sturgeon are expected to be adversely affected by the proposed LTMS Program. Although no data are available to quantify the amount of injury and mortality associated with future implementation of the LTMS Program, NMFS believes that, for the reasons stated herein, the potential level of injury and mortality to green sturgeon and listed anadromous salmonids by dredging and disposal activities in the San Francisco Estuary is very low. It is unlikely that the small potential loss of individuals as a result of the dredging and disposal conducted under the program will impact future adult returns, due to the large number of salmonids and green sturgeon unaffected by the project compared to the small number of fish likely affected by the project. Due to the relatively large number of juveniles produced by each spawning pair, adult salmonids and sturgeon in future years are expected to produce enough juveniles to replace the small number of individuals injured or killed during dredging and disposal activities. It is unlikely that the small potential loss of juveniles during implementation of the LTMS Program will impact future adult returns.

Regarding future climate change effects in the action area, California could be subject to higher average summer air temperatures and lower total precipitation levels. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled. Reductions in the amount of snowfall and rainfall would reduce stream flow levels in Northern and Central Coastal rivers. Estuaries may also experience changes in productivity due to changes in freshwater flows, nutrient cycling, and sediment amounts. For this project, dredging activities would occur over the next 35 years, and the above effects of climate change are likely to begin to be detected within that time frame.

For the LTMS Program, areas affected by dredging and disposal events are generally not of prime importance for foraging by listed fish due to extensive maritime development and changes in estuarine productivity associated with climate change at these sites would, thus, be of lesser significance. Changes in nutrient cycling and sedimentation amounts due to climate change will likely be difficult to detect at LTMS dredging and disposal sites because these locations are regularly disturbed by periodic dredging and placement of dredged sediments. Additionally, proposed dredging and disposal activities will not affect water temperature, freshwater flows, or tidal flows in the San Francisco Estuary. For these reasons, future LTMS Program activities conducted in accordance with the above programmatic measures will not exacerbate the effects of climate change.

Long-term benefits to tidal marsh habitat in the action area are expected through the LTMS Program's placement of dredged material at beneficial re-use sites. The program's measures which require placement of dredged sediments at beneficial re-use sites for all projects conducted outside the work window are expected to accelerate the completion of several large restoration projects. Once completed, tidal wetland restoration sites are expected to benefit listed anadromous salmonids, green sturgeon and designated critical habitat by increasing the productivity of prey species, expanding the amount of forage area, and improving water quality around the San Francisco Estuary.

2.7 Conclusion

After reviewing the best available scientific and commercial data, the current status of threatened CCC steelhead, threatened CCV steelhead, threatened CV spring-run Chinook salmon, endangered Sacramento River winter-run Chinook salmon, and threatened southern DPS green sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the LTMS Program dredging and disposal activities in the San Francisco Bay Region are not likely to jeopardize the continued existence of threatened CCC steelhead, threatened CCV steelhead, threatened CV spring-run Chinook salmon, endangered Sacramento River winter-run Chinook salmon, and threatened southern DPS green sturgeon.

After reviewing the best available scientific and commercial data, the current status of Sacramento River winter-run Chinook salmon, CCC steelhead, and southern DPS green sturgeon critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' opinion that the LTMS Program dredging and disposal activities in the San Francisco Bay Region are not likely to adversely modify or destroy critical habitat for CCC steelhead, Sacramento River winter-run Chinook salmon, and southern DPS green sturgeon.

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 in association with LTMS Program dredging and in-bay disposal activities. Incidental take in the form of injury and/or mortality of threatened CCC steelhead, threatened CCV steelhead, threatened CV spring-run Chinook salmon, endangered Sacramento River winter-run Chinook salmon, and threatened southern DPS green sturgeon is anticipated. Sediment plumes associated with operation of dredges and disposal events are expected to result in incidental take ranging from injury and mortality of adult and smolt listed anadromous salmonids and threatened green sturgeon. Entrainment at hydraulic dredges is expected to result in the mortality of juvenile listed salmonids and green sturgeon.

NMFS was not able to estimate the specific number of CCC steelhead, CCV steelhead, CV spring-run Chinook salmon, winter-run Chinook salmon, and green sturgeon that may be incidentally taken by the proposed action. Monitoring or measuring the number of listed fish actually injured and/or killed by high concentrations of suspended sediment and entrainment during dredging and disposal activities is not feasible. Entrained fish will be carried away in a slurry of dredged sediments and placed at a disposal site which renders their losses as undetectable. Therefore, the number of affected listed fish is difficult to quantify. Due to the difficulty in quantifying the number of listed fish that could be affected by the LTMS Program, a surrogate measure of take is necessary to establish a limit to the take exempted by this incidental take statement. For this action, compliance with the expected in-bay dredged material disposal volume limit is the best surrogate measure for incidental take associated with implementation of the LTMS Program. The amount of dredged material disposed in-bay provides a measure of the extent of dredging performed and sediment plumes at disposal sites. Since both these activities are sources of incidental take, annual in-bay disposal volumes will provide a meaningful measure to assess the incidental take of listed anadromous salmonids and green sturgeon. Therefore, NMFS will consider the extent of take exceeded if LTMS Program in-bay disposal of dredged material exceeds a volume limit of 1.5 million cubic yards per year[6].

[6] The in-bay disposal target volume is 1.25 million cubic yards; however a contingency volume of 250,000 cubic yards has been established for emergencies when sedimentation or other factors result in unanticipated material volumes.

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). NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of CCC steelhead,CCV steelhead, CV spring-run Chinook salmon, and Sacramento River winter-run Chinook salmon:

1. Ensure dredging best management practices are properly implemented.

2. Prepare and submit annual reports regarding dredging and disposal activities performed under LTMS.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps and EPA must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps and EPA 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.

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

a. The Corps and/or EPA must include as permit conditions in authorizations for dredging all appropriate LTMS Program measures and best management practices presented in October 2014 LTMS Program updated project description.

The following terms and conditions implements reasonable and prudent measure 2:

a. The Corps and/or EPA must provide the following information as an annual report to NMFS by June 15 of the following year. The reports shall be submitted to NMFS North Central Coast Office, Attention: NCCO Supervisor, 777 Sonoma Avenue, Room 325, Santa Rosa, California, 95404-6528. The report must contain, at a minimum, the following information:

    i. **Dredging Episode Data.** For each dredging episode conducted during the previous year: project location, start and end date of dredging, amount of material dredged, and disposal location(s).

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). NMFS has the following conservation recommendation:

1. Perform modifications to the Corps' hopper dredges, *Essayons* and the *Yaqunia,* which will allow these vessels to offload dredged materials via pipelines and pumps directly to an upland or beneficial reuse site.

2.10 Reinitiation Notice

This concludes formal consultation for the LTMS dredging and disposal activities in the San Francisco Bay Region, California.

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.

3.0 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

3.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA). Other interested users could include San Francisco Bay Regional Water Quality Control Board and Bay Conservation and Development Commission. Individual copies of this opinion were provided to the Corps and EPA. 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.

3.2 Integrity

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

3.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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