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

August 27, 2015 **Refer to NMFS No:** WCR-2015-2708

James B. Richards
Deputy Director Environmental Planning and Engineering
Office of Natural Sciences and Permits
California Department of Transportation
111 Grand Avenue
Oakland, California 94623-0660

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the reinitiation of the San Francisco-Oakland Bay Bridge Seismic Safety Project to address the Pier 3 Demonstration Project

Dear Mr. Richards:

Thank you for the California Department of Transportation's (Caltrans) letter of February 17, 2015, requesting reinitiation of formal consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.), and the Essential Fish Habitat (EFH) provisions of the Magnuson Stevens Fishery Conservation and Management Act (MSA) for the San Francisco-Oakland Bay Bridge Seismic Safety Project's Pier E3 Demonstration Project, located in San Francisco Bay, California. Effective October 1, 2012, Caltrans is now acting as the lead agency as per the Memorandum of Understanding (MOU) between the Federal Highway Administration (FHWA) and Caltrans pursuant to the Moving Ahead for Progress in the 21st Century Act (MAP-21).

Caltrans is reinitiating consultation on the San Francisco-Oakland Bay Bridge East Span Seismic Project in order to address the impact of removing the pier E3 foundation (Demonstration Project) through the use of controlled charges (explosives) on ESA-listed salmonids, North American southern Distinct Population Segment (DPS) green sturgeon, and their respective critical habitats. Caltrans is also requesting consultation under the provisions of the MSA regarding potential effects to EFH. The enclosed biological opinion is based on our review of the remaining project activities and Caltrans' proposal to conduct a pilot demolition project to remove the Pier E3 of the old San Francisco Oakland Bay Bridge with the use of underwater explosives (*i.e.,* controlled charges). This method for demolition and bridge removal was not included in the project description covered in previous consultations. The biological opinion describes NMFS' analysis of the entire project's potential effects on the following listed species (Evolutionary Significant Units [ESU] or DPS), and designated critical habitat, in accordance with section 7 of the ESA: Central Valley steelhead DPS

(*0ncorhynchus mykiss*), Central California Coast steelhead DPS (*0. mykiss*), Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*), Central Valley spring-run Chinook salmon ESU (*0. tshawytscha*), and North American green sturgeon southern DPS (*Acipenser medirostris*).

In the enclosed biological opinion, NMFS concludes the project is not likely to jeopardize the continued existence of these listed salmonid or green sturgeon species. NMFS also concluded the proposed project is not likely to result in the destruction or adverse modification of the critical habitats for the species listed above. However, NMFS anticipates take of these species will occur as a result of this project. An incidental take statement, which applies to this project with non-discretionary terms and conditions, is included with the enclosed biological opinion.

We completed pre-dissemination review of this biological opinion using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The 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.

NMFS has also reviewed the proposed project for potential effects on EFH and determined that the proposed project would adversely affect EFH for various federally managed fish species under the Pacific Salmon, Coastal Pelagic, and Pacific Groundfish Fishery Management Plans. The proposed action contains measures to avoid, minimize, mitigate, or otherwise offset some potential adverse effects to EFH. No additional EFH Conservation Recommendations are provided by NMFS, as adverse effects to EFH are expected to be adequately minimized or compensated.

Please contact Jacqueline Meyer at 707-575-6057 or jacqueline.pearson-meyer@noaa.gov if you have any questions, or if you require additional information regarding this biological opinion.

Sincerely,

For Gary Stern

William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Jane Hicks, U.S. Army Corps of Engineers
Arn Arnborg, CDFW
Bob Batha, BCDC
Copy to file ARN#: 151422SWR1999SR190
Copy to Chron File

---

[1] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR-2015-2708.

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

San Francisco-Oakland Bay Bridge (SFOBB) Pier E3 Demonstration Project
NMFS Consultation Number: WCR-2015-2708
Action Agency: California Department of Transportation, District 4

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?
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

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Groundfish	Yes	No
Pacific Coast Salmon	Yes	No
Coastal Pelagic	Yes	No

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

Issued By: for [signature]
William W. Stelle, Jr.
Regional Administrator

Date: August 27, 2015

Table of Contents

LIST OF ACRONYMS

BA	Biological Assessment
BCDC	Bay Conservation and Development Commission
BRT	Biological Review Team
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
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
MLLW	mean lower low water
mm	millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
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
SSC	suspended sediment concentrations
TL	total length
USFWS	United States Fish and Wildlife Service

1.0 INTRODUCTION

1.1 Background

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

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts[2]). A complete record of this consultation is on file at NMFS' Santa Rosa California Office.

1.2 Consultation History

In 1998, the California Department of Transportation (Caltrans) proposed to construct a new east span of the San Francisco-Oakland Bay Bridge (SFOBB), approximately 2.18 miles (3.5 kilometers) long, to the north of the existing east span, in order to meet lifeline[3] criteria for providing emergency relief access following a maximum credible earthquake (MCE). An MCE is the largest earthquake reasonably capable of occurring based on current geological knowledge.

On October 31, 2001, formal section 7 consultation between NMFS and the Federal Highways Administration (FHWA) for the SFOBB East Span Seismic Project was completed with the issuance of a biological opinion (BO). NMFS analyzed the effects of the proposed construction of the SFOBB East Span Seismic Project on Central Valley steelhead, Central California Coast steelhead, and Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central California Coast coho salmon, and the critical habitat designated for these species, in accordance with section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.).

Consultation history for the period of September 1998 through October 2001 is documented in the original October 2001 BO. Since the October 31, 2001 BO was issued, consultation has been

[2] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR-2015-2708

3 Lifelines in this context are systems and facilities critical to emergency response and recovery after a natural disaster, including hospitals, fire control and policing, food distribution, communication, electric power, liquid fuel, natural gas, transportation (airports, highways, ports, rail, and transit), water and wastewater. In the case of the East Span, a lifeline connection would provide for post-earthquake relief access linking major population centers, emergency relief routes, emergency supply and staging centers, and intermodal links to major distribution centers. The East Span would be serviceable soon after a maximum credible earthquake.

reinitiated eleven times (2003 through 2015) with NMFS to address proposed changes to the project, and to address impacts of the project to Federally-listed species. The most recent consultation was completed in February 2012. The primary concerns with the project considered in these earlier BOs were activities causing impacts to ESA-listed anadromous species and their designated critical habitats from both temporary and permanent impacts associated with sound pressure exposure from pile driving for permanent pile installation, bridge dismantling, and loss or disturbance of aquatic habitat via degradation of eelgrass beds and benthic substrates from dredging activities, placement of temporary and permanent fill, and turbidity and sedimentation. The previous biological opinions issued for the SFOBB Project covered the construction of the new bridge and dismantling of the original east span via mechanical methods. The construction of the new bridge, immediately north of the original east span (Figure 1), was completed in 2013.

In 2012, Caltrans amended the SFOBB Project's existing permits and consulted with NMFS to build temporary trestles and falsework to facilitate the dismantling of the original east span. However, the consultation did not cover the use of controlled implosion as a removal method. For this reason, Caltrans is seeking reinitiation of consultation for the use of controlled charges (Demonstration Project) to dismantle the Pier E3 marine foundation. These effects, and effects from the remaining demolition work, will be considered in this opinion for salmonids, green sturgeon, their critical habitats and EFH.

Figure 1. SFOBB East Span Seismic Safety Project Map (Caltrans 2015a).

Between March 27, 2014 and January 28, 2015, several meetings, telephone conference calls, and electronic mail (e-mail) communications were exchanged between NMFS, Caltrans, and other state and federal permitting agencies regarding the Demonstration Project's proposed activities. By letter dated February 17, 2015, Caltrans requested reinitiation of consultation for the SFOBB to address the use of the Demonstration Project to remove the Pier E3 of the old SFOBB. This reinitiation request was received by NMFS on February 25, 2015. Caltrans is reinitiating consultation on the SFOBB East Span Seismic Project in order to address the impact of removing the pier E3 foundation (Demonstration Project) through the use of controlled charges (explosives) on ESA-listed salmonids, North American southern DPS green sturgeon, and their respective critical habitats. Caltrans is also requesting consultation under the provisions of the MSA regarding potential effects to EFH.

Several meetings, telephone conference calls, and e-mail communications were exchanged between February 2015 and June 2015 regarding the proposed Demonstration Project, blast plan, attenuation methods and required hydroacoustic monitoring. NMFS requested additional information on sound pressure conversions by e-mail May 7, 2015, and received the additional information by e-mail on May 15, 2015. In May 2015, Caltrans modified the Demonstration Project's scope of work and hydroacoustic monitoring plan which included changes to the project description and expected work window. NMFS requested the additional information via emails and phone conversations on May 29 and June 2, 2015. The additional information was received on June 5, 2015 and consultation was initiated.

1.3 Proposed Action

Caltrans is proposing changes to the remaining construction work for the SFOBB East Span Seismic Project. Specifically, Caltrans would remove Pier E3 by use of controlled charges to implode the pier into its open cellular chambers below the mudline. Given the complexity of removing the deep water caissons, Caltrans is proposing the Demonstration Project to evaluate in-water controlled implosion techniques for the removal of marine foundations. The Demonstration Project expects to reduce the extent and duration of environmental impacts compared to currently permitted conventional bridge dismantling methods; which would employ large cofferdams with extensive amounts of associated pile driving and dewatering, occurring over multiple seasons. As described above, NMFS consulted under section 7 of the ESA with Caltrans on these methods in 2012. The use of controlled charges is expected to greatly reduce in-water work periods and shorten the overall duration of marine foundation removal. The entire Demonstration Project is expected to last approximately seven months, beginning in June 2015 and ending by December 15, 2015. The implosion (underwater blast) of Pier E3 will occur in November. To help minimize impacts to biological resources, the controlled implosion event will be conducted during an ebb tide. The Demonstration Project activities include: 1) Dismantling of Pier E3, 2) Sound Pressure Attenuation through use of a Blast Attenuation System (BAS), and 3) Debris Removal. The structure of the old east span, methods for the activities proposed under the Demonstration Project, and the other remaining activities to remove the old bridge, are described below.

1.3.1 Structure of the East Span

Construction of the original east span connecting Yerba Buena Island (YBI) and the Oakland shoreline was completed in 1936. The original east span is supported by 22 in-water bridge piers (Piers E2 through E22), as well as land-based bridge piers and bents on both YBI and Oakland. As shown in Figure 2 below, the original east span is divided into three major sections.

The in-water or marine foundations vary in type. Piers E2 through E5 consist of concrete caissons founded on deep bedrock. Piers E6 through E22 consist of lightly reinforced concrete foundations that are supported by timber piles. Dismantling of the SFOBB original east span began in late 2013. Demolition work for the marine foundation removal work began in May 2015.[4] Pier E3 has been selected for demonstrating the effective use of controlled charges in water to remove the marine foundations because it is the first marine foundation that will be accessible for dismantling during the bridge removal process.

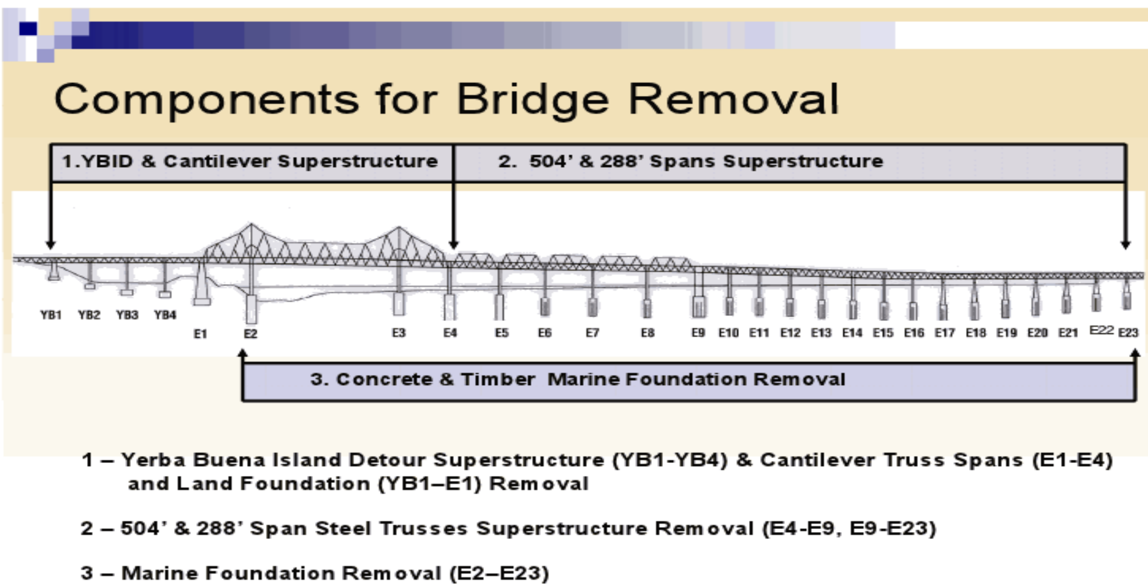

Figure 2. Schematic of the Existing East Span

The Pier E3 caisson is a cellular concrete structure approximately 268 feet (82 meters) tall containing 22 individual rectangular chambers and six irregular shaped chambers on the outer portion of caisson cells that occur below -51 feet (referenced to the 1929 National Geodetic Vertical Datum [NGVD 29]). Its cutting edge (deepest part of the caisson) is at -231 feet. About 175 feet (53 meters) of the structure's height is buried in bay mud. Fourteen of the cells extend above the mudline and support the pier cap and concrete pedestals (Figure 5). During construction, the caisson was constructed on land and then towed to its current location before being sunk into place. Weep holes in the foundation located at an approximate elevation of -5 feet have allowed these chambers to fill with water. The water line inside the caisson varies with the tide, but +1.5 feet was the most common elevation measured in a recent Caltrans' sampling study of the caisson cell water.

Top dimensions of the pier cap are 80 feet (24 meters) by 134.5 feet (41 meters), not including the fender apron. Exterior walls along the perimeter of the caisson are four feet (1.2 meters) wide, while the interior walls comprising the rectangular chambers are three feet (1 meter) in width. The mudline (*e.g.*, the bottom of the bay floor) at Pier E3 ranges in elevation from -43 to

[4] The effects of demolition work underway in May 2015 were analyzed in prior biological opinions, most recently the February 6, 2012 biological opinion for the project.

-51 feet. The pier cap, fender system and upper most portions extend above the water line to support the steel superstructure of the cantilever section and are visible from the Bay.

1.3.2 Dismantling of Pier E3

The implosion and dismantling of Pier E3 will take place in four phases:

1) Dismantling of pier cap and fender system.
2) Drilling of bore holes into caisson and buttress walls and installing a BAS.
3) Installing charges, activating the BAS and imploding the pier.
4) Management and removal of remaining dismantling debris.

Dismantling activities for Pier E3 will follow the removal of the SFOBB cantilever truss section (Figure 1) and steel support tower on the original east span. This work began in June 2015 (the effects of these activities were analyzed in the 2012 biological opinion). The basic steps for Pier E3 dismantling will involve removing the timber and steel-supported fender system that surrounds Pier E3, dismantling of the concrete pier cap by mechanical means to an elevation of +9 feet and drilling vertical boreholes to load charges for the controlled implosion.

Support platforms will be installed atop the caisson over the open cells of the columns (Figure 3) to provide a working surface for the hoe rams to dismantle the upper portion of Pier E3. Support barges will be used to move hydraulic excavators (equipped with hoe rams and shearing attachments and other equipment needed for dismantling), cutting lances and torches to Pier E3. Support barges will be anchored and remain onsite for the duration of the Demonstration Project. Platforms will be installed and relocated to allow excavators to access the top of the pier to dismantle the remaining concrete to the final mechanical dismantling elevation limit. The excavators and other equipment will be lifted onto the top of Pier E3 with a barge-mounted crane. Pier E3 mechanical dismantling process will remove the concrete pedestals and pier cap to expose the inner cells (Figure 4). The fender system will be removed including timber, metal framing and concrete apron. All metal and timber will be disposed of offsite. A debris catchment system will be used to contain any concrete debris from discharging into the Bay. Concrete rubble from the concrete pedestal and apron dismantling will be disposed of inside the exposed inner cells of the pier.

All debris is expected to fall to the base of the caisson, well below mudline. This disposal method is congruous with the SFOBB Project Final Environmental Impact Statement (FEIS), which states that Caltrans may “use the hollow interiors of the columns remaining below the mudline as receptacles for pieces of concrete. As the upper portion of the column is dismantled, pieces of concrete could fall into the hollow interiors below the mudline.” Once the demolition is over, it is expected for the Bay sediment to quickly fill in the caisson voids and bury debris within the cells.

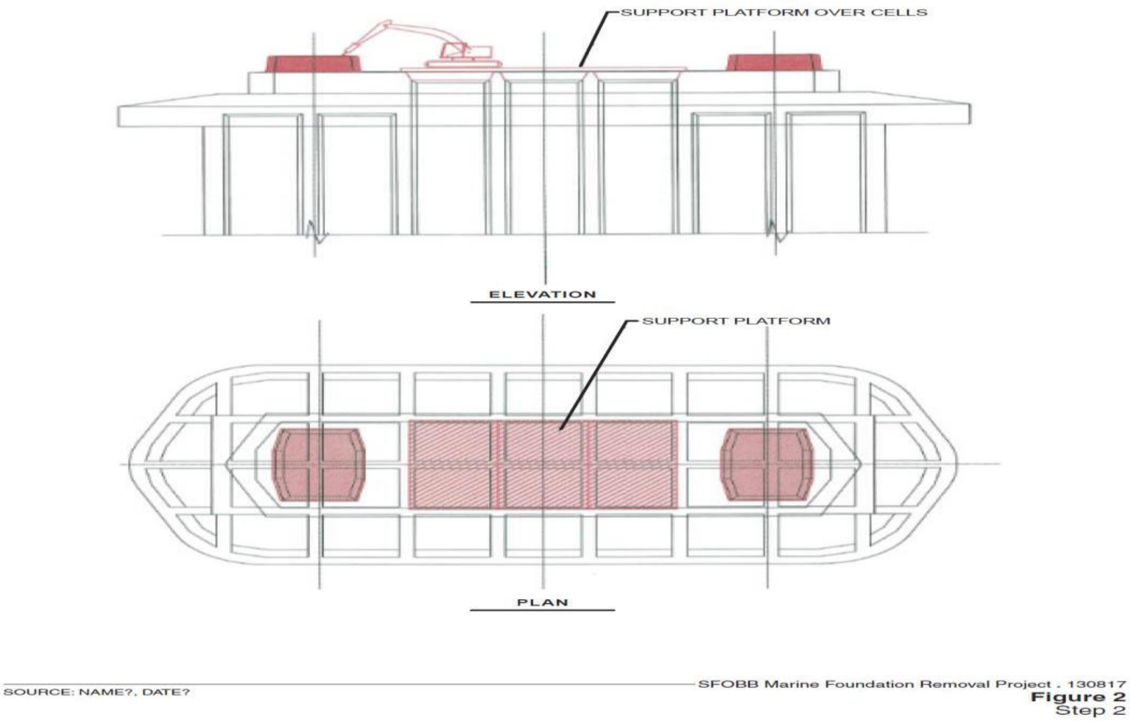

Figure 3. Pier E3 schematic. Elevation view depicts an excavator equipped with a hoe ram is shown dismantling a concrete pedestal. Plan view shows installed support platform over open cells to support construction equipment used for dismantling (Caltrans 2015a).

1.3.3 Drilling Boreholes

Once the pier has been dismantled to the mechanical dismantling elevation, access platforms will be installed to support the drilling equipment while exposing the top of the interior cells and outside walls. Borehole drill locations will be marked on the inner cell walls and exterior walls of the pier. The holes will be drilled to elevation -55 feet and -77 feet and spaced about 4.5 feet apart. A total number of 150 holes will be drilled, ranging in diameter from 2.75 – 3 inches. An overhanging template system will be installed to guide the drill below the waterline. Divers will be required to cut notches to guide the drilling of underwater boreholes. A concrete drill rig will be used to drill holes into the interior and exterior cell walls consistent with the Blast Plan provided by Caltrans in the February 2015 biological assessment (BA) for the Demonstration Project.

1.3.4 Placement of Charges and Blast Sequence

Controlled implosion will be accomplished using hundreds of small charges with delays between individual charges. Charges will be loaded into the drilled boreholes. The entire detonation sequence of controlled implosion charges will last approximately four to six seconds and will remove the pier to, or below, the current surrounding scour elevation of -51 feet. The target elevation for removal will be to an elevation of -77 (interior walls only). The maximum pounds of explosive per charge delay will be 35 pounds, for a total explosives weight of 16,875.6 pounds. There will be a total of 588 detonations, with a delay separation of 9 milliseconds, for a total expected shot time of 5.3 seconds. The sequence of the detonation will be fired from bottom to top, and the blast will initiate in the interior of the pier and progress sequentially to the outside. To minimize impacts to aquatic biological resources in the Bay, a BAS will be installed around the base of the pier to reduce the area where high sound pressure levels can propagate from the blast. The bubble flux of the BAS will also help control sediment and turbidity generated by the implosion surrounding Pier E3.

An additional test blast will be conducted to test the sound activation triggers required for the hydrophones needed for hydroacoustic monitoring of the blast. This will be a single test blast and will be detonated shortly before the actual implosion event. Detonation of the test charge will occur at least three to four days prior to the actual implosion and after the BAS is in place and functional. The test will use a charge weight of 18 grain (0.0025 lbs.) or less. The charge will be placed along one of the longer faces of the Pier and inside the BAS while it is operating. The charge will be positioned near the center of the wider face of the pier to shield the areas on the opposite side as much as possible from sound. Acoustic measurements during the test blast will be made with the same transducers and instrumentation to be used for the near and far field monitoring of the actual implosion. After the test, the results will be evaluated to determine if any final adjustments are needed in the sound measurement systems prior to the implosion.

1.3.5 Blast Attenuation System (BAS)

The BAS is specifically designed to minimize noise and pressure impacts generated by the controlled implosion. Installation of the BAS will be concurrent with the borehole drilling process. The BAS will be installed during drilling operations. The BAS to be used at Pier E3 is a modular system of pipe manifold frames that will be fed by 14, 1600-cubic-feet-per-meter (cfm) air compressors to create a curtain of air bubbles around the entire pier during the controlled implosion. Each BAS frame will be lowered to the bottom of the Bay by a barge mounted crane and positioned into place (Figure 4).

Divers will be used to assist frame placement and to connect air hoses to the frames. Based on location around the pier, the BAS frame elements will be situated from approximately 25 feet (7.6 meters) to 40 feet (12 meters) from the outside edge of Pier E3. The frames will be situated to contiguously surround the pier; frame ends will overlap to ensure no break in the BAS when operational. Each frame will be weighted to negative buoyancy for activation. Air compressors will provide enough pressure to achieve a minimal air volume fraction of three to four percent (%), consistent with the successful use of BAS systems. System performance is anticipated to provide approximately 80% attenuation, or better, based on past experience with similar systems during controlled blasting. Each BAS frame will be fed by an individual compressor mounted on a barge. This will require 14 compressors on approximately 14 flexi-float barges situated around the pier. Each barge will be temporarily anchored to maintain their position around the pier. Compressors will be turned on and each section of the BAS will be tested for uniform air flow prior to the controlled implosion. Once the controlled implosion event has been completed, the contractor will demobilize the BAS and all associated equipment.

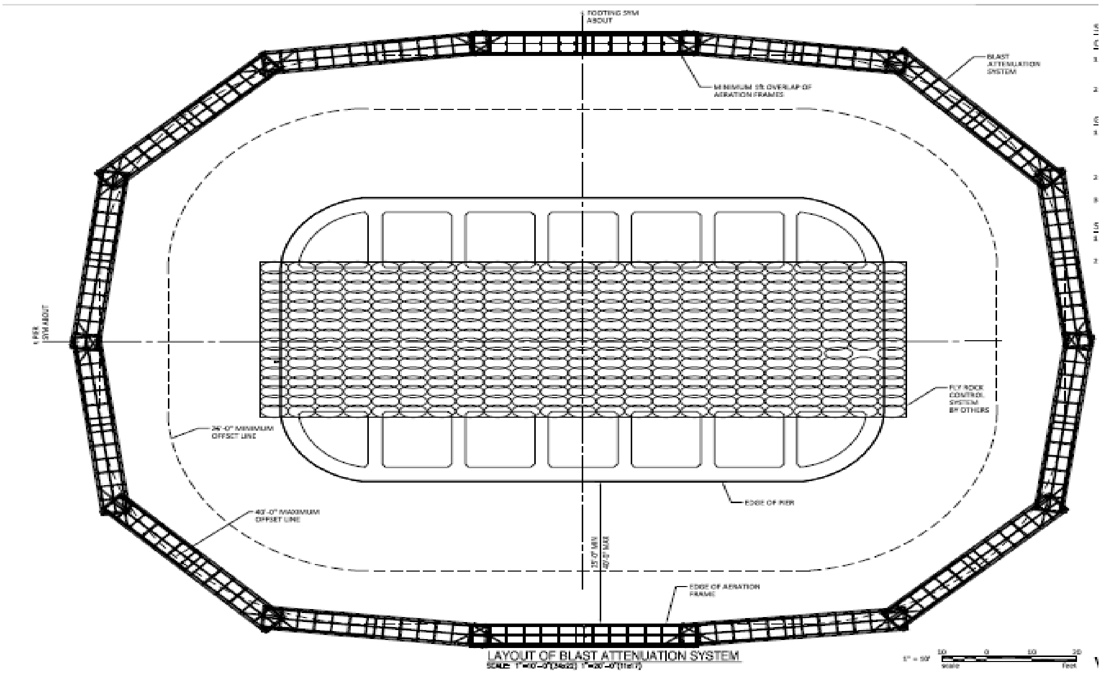

Figure 4. The Blast Attenuation System Layout (Caltrans 2015a).

1.3.6 Management and Removal of Debris.

Following the completion of the dismantling activities, any concrete debris remaining above the scour line on the Bay substrate will be removed. Debris will be removed or excavated from the substrate to the current scour line elevation of -51 feet and brought to the surface to be processed. Removal of rubble will be performed with mechanical dredging techniques (*e.g.*, clam shell dredge) as opposed to hydraulic dredging, to avoid entrainment of fish. Any rebar will be removed to minimize bridging of open caisson cells. Processed debris will then be placed into the open voids of the caisson for disposal.

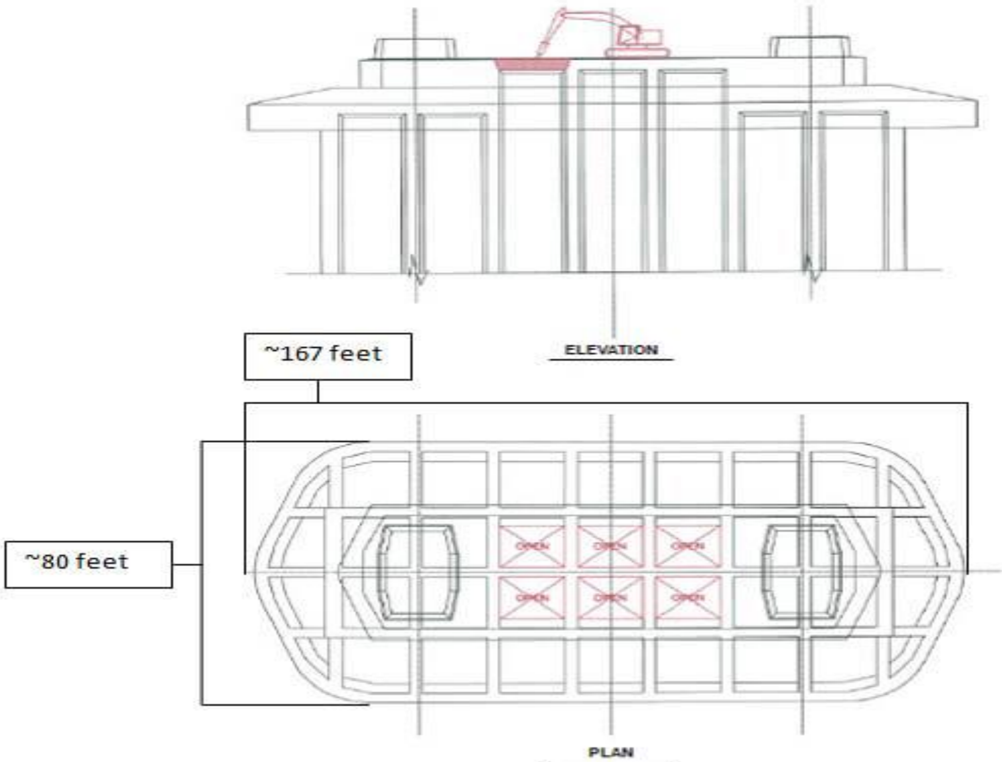

Figure 5. Schematic of Pier E3 elevation view, excavator is shown atop the pier cap removing the top slab of concrete to expose the inner cells of the pier. Exposed inner cells are depicted in the plan view (Caltrans 2015a).

1.3.7 Avoidance and Minimization

Measures to avoid and minimize effects to federally listed species and their habitats, Caltrans will implement the following measures:

1. Blast Attenuation System (BAS). A BAS will be deployed around Pier E3 to reduce the velocity of sound pressure waves, and reduce the distance that deleterious sound pressure levels may propagate from the blast, and reduce the number of individuals and habitat areas subject to harmful sound levels. Minimal efficiency of the BAS for reducing blast wave pressures is conservatively estimated at 80%, based on the performance of similar systems.

2. Hydroacoustic Monitoring: Actual efficiency during the implosion will be evaluated through hydroacoustic monitoring. The measurements will be used to determine calculated distances to reach sound pressure thresholds for fish, to verify sound propagation modeled for the blast event, and to ensure incidental take limits are not exceeded during the implosion.

3. Seasonal Avoidance: To avoid project effects to the highest concentrations of ESA-listed fish species, the Demonstration Project activities will occur within the seasonal work window of June 1st – December 15th, with the controlled implosion of Pier E3 occurring

in November when the vast majority of the ESA-listed species are not likely to be present or only present in extremely low numbers.

4. Bird Predation Monitoring/Fish Salvage. For the project, several bird predation monitors will be positioned to record bird predation activity before, during, and after the Pier E3 implosion. If bird predation is observed, the monitor will initiate one-minute counts of bird strikes. The monitor will attempt to identify the species and sizes of any impacted fish through observation with binoculars. A summary of the findings of the bird predation monitoring will be provided to Caltrans, NMFS, and the California Department of Fish and Wildlife (CDFW) within 72 hours of the Pier E3 implosion. If feasible, any green sturgeon, salmonids, or longfin smelt collected during monitoring will be preserved for transfer to NMFS or CDFW.

5. Physical Disturbance and Shading of Eelgrass. All eelgrass beds in the vicinity of the SFOBB Project have been designated as environmentally sensitive areas (ESAs). To protect and demarcate these ESAs, Caltrans will install and maintain buoys along their outer boundary. To protect eelgrass beds during the Demonstration Project, all project-related equipment (barges, cranes, piles, BAS, *etc*.) will be placed and/or staged outside the eelgrass ESA buoys.

6. Caltrans will include a copy of NMFS' BO within the construction bid package of the proposed project. The Resident Engineer or their designee will be responsible for implementing the Conservation Measures and Terms and Conditions of the NMFS' BO and the CDFW Incidental Take Permit.

7. The CDFW monitoring plan will also require otter trawling be conducted immediately after the implosion to try and salvage any fish that may have been killed from exposure to the underwater blast. All fish that are collected will be identified to species and assessed visually for external damage. Fish that are captured alive and deemed healthy enough for release will be released. Dead or moribund fish will be retained and necropsied. Data will be recorded for all listed fish species captured in the trawl. Salvaged fish may be necropsied to determine if implosion related injuries were the primary cause of death.

8. Pacific Herring Monitoring: As a CDFW-managed fishery and MSA species, Caltrans proposes to use scanning equipment to complete a search of the area around Pier E3 if the implosion or post-implosion work should occur during the pacific herring spawning season. This period has been identified for previous monitoring events as between December 1 and February 28. Submission of a Pacific Herring Work Waiver from CDFW also would be sought for any work completed during this period. The presence of large spawning masses of pacific herring may potentially delay the Pier E3 implosion. If this occurs, Caltrans will consult with NMFS and CDFW to identify another work window to undertake the controlled implosion.

9. Water Quality Monitoring: The implosion and placement of concrete rubble may increase turbidity and displace water within the cells. To appropriately manage water quality

issues created by sediment and any displacement of the caisson cell water, Caltrans will monitor water quality and turbidity during this disposal activity while using appropriate minimization measures to reduce potential deleterious impacts to the surrounding water column. Turbidity monitoring will be performed prior to, during and post mechanical dismantling, drilling, controlled implosion and dredging activities. Monitoring will be conducted in accordance with methods and standards outlined in the Water Quality Self-Monitoring Program required by the Regional Water Quality Control Board (RWQCB) Order No. R2-2002-0011, or as required by the RWQCB. Caltrans will ensure to the extent practical that turbidity generated by activities associated with the Demonstration Project do not exceed 50 nephlometric turbidity units (NTUs) or result in an incremental increase greater than 10% of the background NTU at a distance greater than 30 meters (100 feet) from the activity, when the activity occurs within 1,000 meters (3,200 feet) of an eelgrass bed or sand flat. During the controlled implosion event, additional water quality monitoring will be conducted to detect and measure conductivity and temperature (including data for depth at sample taken), pH, dissolved oxygen, metals, and other contaminants.

10. Worker Environmental Awareness Training: All construction personnel will attend a mandatory environmental education program delivered by an agency-approved biologist prior to working on the project.

1.3.8 Remaining Project Activities

The construction of the new bridge was originally divided among nine separate contracts: 1) Yerba Buena Island Transition Structure (YBIT); 2) Self-Anchored Suspension Span (SAS); 3) SAS Marine Foundations E2 and T1 (E2/T1); 4) Skyway Structure; 5) Oakland Approach Structure; 6) Geofill at the Oakland Touchdown; 7) Submarine Cables; 8) Storm-water Treatment System; and 9) Dismantling of the existing east span. The new bridge construction was completed in 2013. The remaining construction activities include dismantling of the old, existing east span of the bridge, and the removal of Pier E3 is part of the demolition activities. Dismantling of the SFOBB original east span began in late 2013. The dismantling of the original east span has been divided into multiple phases and contracts corresponding to the different sections of the original east span (Figures 1 and 2). The remaining demolition activities are described in detail and analyzed in the February 2012 BO (except for the use of a controlled implosion – the Demonstration Project), and the remaining removal phases include:

- Removal of the Yerba Buena Island Transition Structure No. 2 (YBITS 2),
- Removal of the 504’ and 288’ Truss Spans Superstructure,
- Removal of Marine Foundations.

The first of the above mentioned phases, the YBITS 2 removal, started in late 2013 and involves the dismantling of the YBI Detour structure and Cantilever Span. This phase is 70% complete, and anticipated to be finished November 2016. The second phase, the 504’ and 288’ Truss Spans Superstructure dismantling, commenced work in mid-2015. Demolition work for the marine foundation removal began in May 2015. Caltrans originally thought this phase would require extensive pile driving for temporary construction support structures. However, the current contractor is able to remove larger section of the structure and lower them onto barges rather to be hauled off and dismantled further offsite. This will greatly reduce the number of piles that will be needed for any temporary structures. This phase is expected to be finished by January 2018. The removal of the marine foundations is the last remaining phase to be completed. Pier E3 removal is part of this phase, and has been selected for demonstrating the effective use of controlled charges in water to remove the marine foundations because it is the first marine foundation available for dismantling during the bridge removal process. Removal of the above-water pier structures (*e.g.,* wooden fender systems and pier cap) began in June 2015.

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 in the action (50 CFR § 402.02). The remaining SFOBB activities, including the Demonstration Project, are located in San Francisco Bay, between YBI and Oakland. For these activities NMFS defined the action area to be: 1) the portions of North, Central, and South San Francisco Bay subject to sound pressure waves around Pier E3, determined by hydroacoustic analyses corresponding to distances from pile driving for falsework construction and from Pier E3 subject to impulsive sound pressure thresholds for fish, and 2) the Bay substrate and water column surrounding the old bridge and Pier E3 subjected to temporary elevated turbidity levels. The total action area subjected to high sound pressure waves was derived from hydroacoustic modeling of the blast implosion using the established metrics for the respective thresholds (Figure 6). The entire extent of the sound field covers 56,011 acres, or the predicted distance to reach the 150 dB root-mean-square (RMS) behavioral (sub-injurious) response threshold which corresponds to a radial distance of 68,000 feet from Pier E3. This distance reflects the maximum distance where listed fish and critical habitat may be affected and includes any areas affected by other remaining SFOBB activities. A smaller area of approximately 470 acres within this larger area, extending a radial distance of 777 feet from the pier, would be temporarily subjected to the 187 dB cumulative sound exposure level (cSEL) threshold for onset of injury to fish two grams or larger for the blast. Due to their life histories and size when they are present in the Bay (see Baseline, section 2.3), no ESA fish species within the action area are expected to be smaller than two grams.

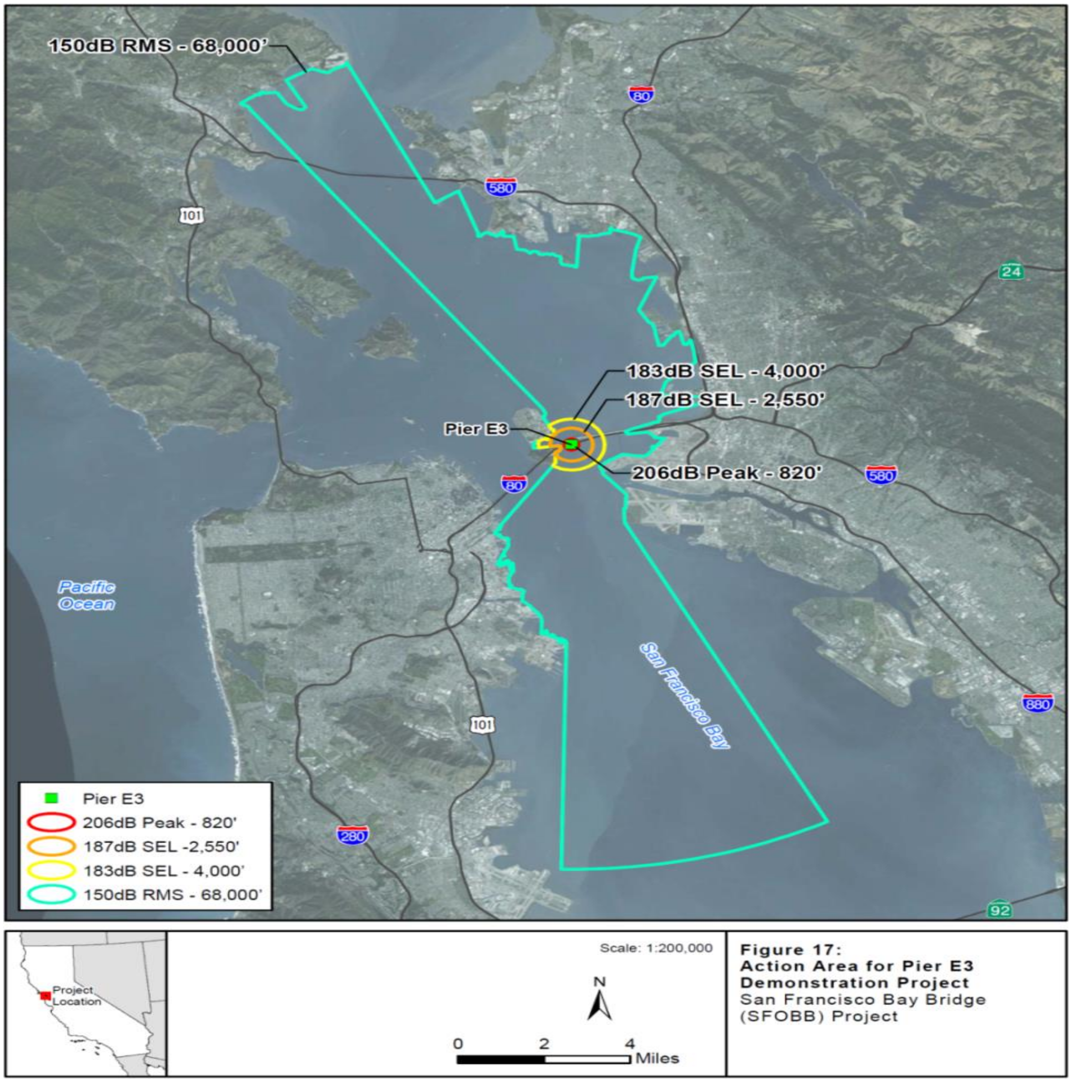

Figure 6. Action Area for Pier E3 Demonstration Project, and Distances to reach sound pressure thresholds (Caltrans 2015a).

The entirety of the action area is within the San Francisco Bay. No terrestrial communities are associated with the proposed Demonstration Project or the remaining elements of the SFOBB Seismic Safety Project. The acreage listed above also includes marine foundations and other in-water bridge supports for the SFOBB (original and new span). This action area has been determined based on the direct and indirect effects of the project's pile driving, underwater explosives, and debris removal and disposal activities needed to dismantle the remaining portions of the existing bridge.

Pier E3 flanks the east side of the approximately 50-foot (15 meters) deep shipping channel of the SFOBB original east span. Figure 7, a schematic of the east span of the SFOBB, shows the cantilever truss span and the location of Pier E3 (circled) relative to other piers on the bridge.

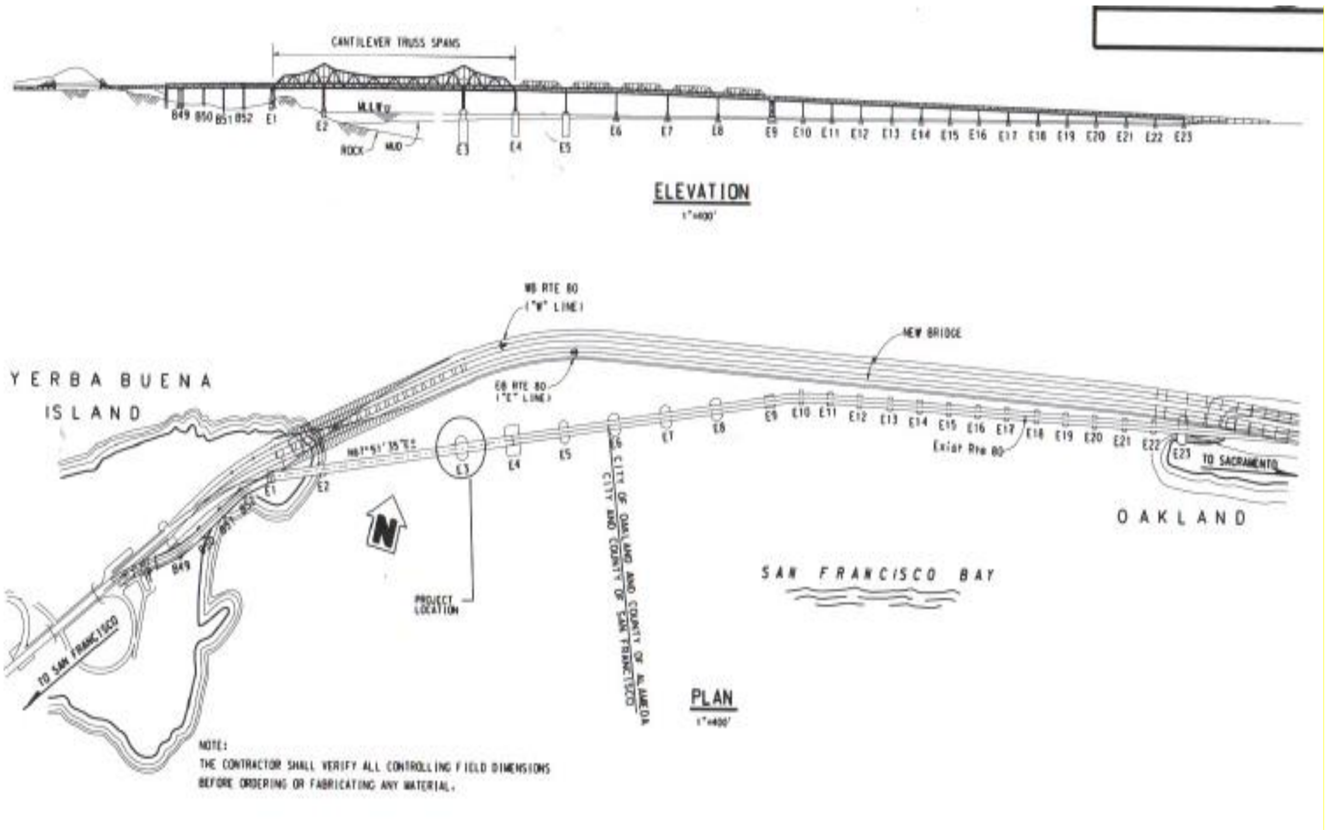

Figure 7. Schematic of the east span of the SFOBB showing the cantilever truss span and the location of Pier E3 (circled) relative to other piers on the bridge.

2.0 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

The proposed action is not likely to adversely affect threatened CV spring-run Chinook salmon Evolutionary Significant Units (ESU), endangered Sacramento River winter-run Chinook Salmon ESU or its critical habitat, threatened CCC steelhead Distinct Population Segments (DPS) or its critical habitat, or the threatened CV steelhead DPS. The analysis for these species is found in the "Not Likely to Adversely Affect" Determinations (section 2.11).

2.1 Analytical Approach

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

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.
We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

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

For critical habitat, NMFS determines the range-wide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PCEs) - which were identified when critical habitat was designated. Species and critical habitat status are discussed in section 2.2 of this biological opinion.

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 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 project's 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 from the Biological Assessment and Essential Fish Habitat Assessment for the San Francisco-Oakland Bay Bridge Pier E3 Demonstration Project, prepared by Garcia and Associates, dated February 2015; and the Supplemental Biological Resources Evaluation for the San Francisco-Oakland Bay Bridge Pier E3 Demonstration Project, prepared by Garcia and Associates, dated March 2014. Information was also provided in e-mails, messages, and telephone conversations between March 2014 and May 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 151422SWR99SR190).

2.2 Rangewide Status of the Species and Critical Habitat

This biological opinion analyzes the effects of the remaining activities associated with the removal of the old east span of the San Francisco-Oakland Bay Bridge, including the Pier E3 Demonstration Project, on the following Federally-listed species (DPS or ESU) and designated critical habitats:

Central Valley steelhead DPS (*Oncorhynchus mykiss*) DPS
Threatened (January 5, 2006, 71 FR 834);
Central California Coast steelhead (*O. mykiss*) DPS
Threatened (71 FR 834; January 5, 2006)
Critical habitat (70 FR 52488; September 2, 2005);
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU
Threatened (June 28, 2005, 70 FR 37160);
Sacramento River Winter-run Chinook salmon (*O. tshawytscha*) ESU
Endangered (70 FR 37160; June 28, 2005)
Critical habitat (58 FR 33212; June 16, 1993); and
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 CV steelhead and CV spring-run Chinook salmon is not present in the action area.

2.2.1 Species Description, Life History, and Status

In this biological opinion, NMFS assesses four population viability parameters to help us understand the status of CV steelhead, CCC 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 CV Spring-run and Sacramento River Winter-run Chinook Salmon General Life History

Chinook salmon return to freshwater to spawn when they are three to eight 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 CV 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). CV spring-run Chinook salmon adults hold in freshwater over summer and spawn in the fall. CV spring-run Chinook salmon juveniles typically spend a year or more in freshwater before migrating to the ocean. Adequate instream flows and cool water temperatures are more critical for the survival of CV 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. CV 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 degrees Celsius (^{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. CV spring-run Chinook salmon fry emerge from November to March and spend about 3 to 15 months in freshwater prior to migrating to 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 after only rearing in freshwater for 4 to 7 months, and occur in the Delta from October through early May (CDFG 2000). Most CV spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 1998).

2.2.1.2 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 CV 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 CV 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.[5] 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.

CV 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 CV 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 CV 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

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

potential impacts from hatchery production, NMFS ultimately concluded the FRH stock should be included in the CV 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 CV spring-run Chinook ESU (Williams *et al*. 2011). Because wild CV spring-run Chinook salmon ESU populations are confined to relatively few remaining watersheds and continue to display broad fluctuations in abundance, the Biological Review Team (BRT) concluded that the ESU is likely to become endangered within the foreseeable future. The most recent status review concludes the status of CV 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 CV spring-run Chinook status again in 2-3 years, (instead of the normal 5 years) if species numbers do not improve (NMFS 2011).

2.2.1.3. 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 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 % 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 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. 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).

2.2.1.4. CV 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 %) in California streams. Steelhead young usually rear in freshwater for one to three years before migrating to the ocean as smolts, but rearing periods of up to seven years have been reported. Migration to the ocean usually occurs in the spring. Steelhead may remain in the ocean for one to five years (two to three 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 °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). Steelhead typically begin returning to the Bay and the Central Valley rivers in late fall, with most immigration occurring from December through February. Spawning takes place from January through April. 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.

2.2.1.5. Status of the CV Steelhead DPS

The CV steelhead historically were well-distributed throughout the Sacramento and San Joaquin rivers (Busby *et al*. 1996). Although it appears CV steelhead remain widely distributed in Sacramento River tributaries, the vast majority of historical spawning areas are currently above impassable dams. At present, all CV 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 CV 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 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 % of returning adults were of natural origin, and this estimate declined to 10-30 % 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 CV steelhead appears to have worsened since the 2005 status review (Good *et al.* 2005), when the 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 CV 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 CV steelhead 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 CCC Steelhead DPS and Critical Habitat

Historically, approximately 70 populations 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. 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.

The 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.

2.2.1.7 Green Sturgeon General Life History

Green sturgeon is an anadromous, long-lived, and bottom-oriented fish species in the family Acipenseridae. Large adults may exceed two 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). 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 6months 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 one to two 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*., one to two 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 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 2002b) 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 (now CDFW) 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 Red Bluff Diversion Dam (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 potentially 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 enumerate 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 (Wang, S. pers. comm. 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

In the past, 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% (range equals 3 - 63 %) 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 % of annual production, whereas mergansers had the potential to remove 5–54 % 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 %, 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).

2.2.2.4 Global Climate Change

Another factor affecting the rangewide status of threatened Southern DPS of North American green sturgeon, threatened CV steelhead, threatened CV 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). Listed salmonids and green sturgeon may have already experienced some detrimental impacts from climate change. NMFS believes the impacts on salmonids listed green sturgeon to date are likely fairly minor because natural climate factors likely still drive most of the climatic conditions green sturgeon experience, and many of these factors have much less influence on green sturgeon abundance and distribution than human disturbance across the landscape.

The threat to salmonids and green sturgeon from global climate change will increase in the future. Modeling of climate change impacts in California suggests that average summer air temperatures are expected to continue to increase (Lindley *et al.* 2007; Moser *et al.* 2012). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe *et al.* 2004, Moser *et al.* 2012; Kadir *et al*. 2013). Total precipitation in California may decline; critically dry years may increase (Lindley *et al.* 2007; Schneider 2007; Moser *et al.* 2012). Wildfires are expected to increase in frequency and magnitude (Westerling *et al.* 2011, Moser *et al.* 2012).

In the San Francisco Bay region, 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 projected 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 project 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 projected to occur in March and April, with the core winter months remaining relatively unchanged (Cayan *et al*. 2012)].

For Northern California, most models project heavier and warmer precipitation. Extreme wet and dry periods are projected, increasing the risk of both flooding and droughts (DWR 2013). Estimates show that snowmelt contribution to runoff in the Sacramento/San Joaquin Delta may decrease by about 20% per decade over the next century (Cloern *et al.* 2011). Many of these changes are likely to further degrade listed salmonid habitat by, for example, reducing streamflows during the summer and raising summer water temperatures. Estuaries may also experience changes detrimental to salmonids. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia *et al.* 2002, Ruggiero et al. 2010). Cloern et al. (2011) estimates that the salinity in San Francisco Bay could increase by 0.30-0.45 practical salinity unit (psu) per decade due to the confounding effects of decreasing freshwater inflow and sea level rise. In marine environments, ecosystems and habitats important to salmonids and green sturgeon are likely to experience changes in temperatures, circulation, water chemistry, and food supplies (Brewer and Barry 2008; Feely 2004; Osgood 2008; Turley 2008; Abdul-Aziz *et al.* 2011; Doney *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 action area is located within San Francisco Bay, California. San Francisco Bay is the largest estuary on the United States 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. Combined with the Sacramento-San Joaquin Delta (Delta), the San Francisco Estuary covers a total surface area of approximately 4100 square kilometers (1622 square miles). Located about halfway up the California coast from the Mexican border, it is the natural discharge point of 40% 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.

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 (SSC) 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). The SSC 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, SSC 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 SSC (Schoellhamer 2001). Most of the Bay within the action area is comprised of small, soft sediment particles that can be moved by tidal currents. Sediment sizes range from clay (0.001 – 0.0039 mm) to silt (0.0039 – 0.0625 mm) to sand (0.0625 – 2 mm); (SFBHG 2010). Mud refers to a mixture of clay and silt together. Larger particles, including gravel (2 – 64 mm) and cobble (64 – 256 mm) also can be found in soft bottomed habitats. Sand deposits can be found through the deeper parts of the Central Bay and the main channel through San Pablo Bay (SFBHG 2010).

The SFOBB Seismic Safety and Demonstration Project will occur in what is generally considered the Central Bay (although some of sound pressure waves will travel into the north and south bays as well). The Central Bay is the deepest basin, is most influenced by the ocean, and has the saltiest water (on average) in the Bay. The deepest point is over 100 meters deep near the Golden Gate Bridge (SFBHG 2010). The Central Bay has the most marine species in the Bay and probably the highest species diversity. The marine environment around the SFOBB and Pier E3 consists of largely open water (pelagic) habitat along with subtidal and intertidal habitats closer to YBI and Treasure Island. Within intertidal zones, eelgrass (*Zostera marina*) beds occur along the northeast and east sides of Treasure Island and within Clipper Cove, adjacent to the northeast shore of YBI (City & County of San Francisco 2010). Additionally, there are historical records of eelgrass beds from 1999 and 2005 immediately off the southeastern shores of YBI (Merkel & Associates 2008). Subtidal habitats near Pier E3 are classified as soft mud and sandy bottoms with occasional rocks and cobbles, which vary in composition depending on distance from the shore (City & County of San Francisco 2010). Eelgrass can also occupy the subtidal zone.

In October 2014, water and sediment samples were collected from the Pier E3 caisson. Details of the sampling and analytical methods, including quality control procedures, used to investigate the caisson water quality were provided in Pier E3 Caisson Water Quality technical memorandum (AMEC Foster Wheeler 2015). Conductivity, pH, temperature, turbidity and dissolved oxygen were measured at regular intervals from the water surface to the bottom of the caisson and discrete water samples were collected at three depths. Two samples of ambient Bay water were also collected from the southeast and northeast corners of a barge near the Demonstration Project area. Results of the caisson sampling program indicated that except for a small volume of water near the water line, caisson water quality appears to be reasonably comparable to ambient Bay water and below regulatory trigger limits. Near the water surface there is a depression of dissolved oxygen in all caissons and elevated lead, zinc, and silver in selected caissons. Lead concentrations exceeded the trigger limit at the lowest sampling depth (approximately 185 to 195 feet in depth) for six of the 10 caissons; this depth is well below the Pier E3 removal depth of -77 feet. The pH was generally in a narrow range between 7.5 and 8. Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and pesticides were generally not detected or were detected at unquantifiable low concentrations.

The open water environment around YBI and Treasure Island is almost entirely marine in composition due to a lack of significant freshwater flow (City & County of San Francisco 2010). Numerous fish and marine mammals are known to occupy the Bay and are likely to occur, at some point in their life cycle, around the original east span of the SFOBB, including Pier E3. Additionally, many bird species are known to forage and nest throughout this area.

2.3.2 Status of Species and Critical Habitat in Action Area

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

The action area includes the north, central and south San Francisco Bay, with the majority of project activities occurring in central San Francisco Bay. Central San Francisco Bay, including the action area, is within the designated critical habitat for CCC steelhead and Sacramento River winter-run Chinook salmon. The action area is used primarily as a migration corridor by listed CV steelhead, CCC 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 CV 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 CV 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 CV 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 CV late fall-run Chinook salmon and CV 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 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 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). Sacramento winter-run juveniles may begin to enter the Bay, and potentially occur around Pier E3 and elsewhere in the action area from December through June, and CV spring-run Chinook juveniles typically emigrate during the spring and begin to enter the Bay.

In the Bay Study, Chinook were captured in the mid-water trawl in both the deeper and shallow habitats, but were not captured in the otter (bottom) trawl. Few if any adult Chinook are expected near Pier E3 since this area is away from the migratory corridor they use to reach their spawning areas. Studies of tagged late-fall juvenile Chinook salmon released in the spring showed 0.6% and 1.6% of all individuals (500 total) were detected at the east span of the SFOBB in 2009 and 2010, respectively (Hearn *et al.* 2010). 2010 was a wetter year than 2009, with proportionally greater outflow from the Sacramento and San Joaquin rivers. Therefore, occurrence of juvenile Chinook at the Bay Bridge in 2010 may have been correlated with more fish being pushed to the south during periods of high freshwater outflow.

Steelhead are known to occur in the western tributaries leading into the Bay. Historically they occurred in San Leandro Creek, south of the old (east) span including Pier E3, and other streams along the eastern shore of the central and south bay. Steelhead, however, occur infrequently within the area around the old span and Pier E3. There are no occurrences of steelhead in the Bay Study trawl data from 1980 through 2012 for the four sites closest to Pier E3. Studies of tagged CV steelhead smolts released in the spring showed 1.8% and 1.6% of all individuals (500 total) were detected at the east span of the SFOBB in 2009 and 2010, respectively (Hearn *et al.* 2010). Like chinook, the presence of steelhead around SFOBB may have been driven by stronger freshwater flows from spring rains, which pushed individual smolts further south. These freshwater flows are rainfall dependent and therefore seasonal. Typically, the fall is a low-flow period except during large storm events.

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. However, juvenile Chinook salmon are infrequently found near the old span and Pier E3 between March and August based on the Bay Study. Trawl data from the Bay Study recorded a total of 94 individuals captured in the four sites closest to the old span and Pier E3 between 1980 and 2012.

Based on life history patterns, seasonal distribution and migration patterns, and trawls data presented in the Bay study, adult and juvenile CV spring-run and Sacramento winter-run Chinook salmon are not expected to be present in the action area during the Demonstration Project's implosion activities, but could be transiting through the action area in the winter and spring months (December 1st – May 31st) when some pile proofing and debris removal activities occur. Juvenile Chinook salmon may also be present during pile driving activities. Both CV steelhead and CCC steelhead are known to occur near Pier E3, however due to their typical migration patterns and life history traits, are unlikely to be present in the action area during the implosion of Pier E3. CCC steelhead and CV steelhead are expected to be transiting through the action area during pile proofing and debris removal activities in the winter and spring months.

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

The action area is designated critical habitat for CCC steelhead and Sacramento winter-run Chinook salmon. Designated critical habitat for CCC steelhead includes all aquatic habitat within the action area. Within the action area, essential features of critical habitat 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, and periodic dredging for navigation.

Features of designated critical habitat for Sacramento 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 partially 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, and periodic dredging for navigation.

2.3.2.3 Green Sturgeon

Green sturgeon are iteroparous[6], and adults pass through the San Francisco Bay estuary during spawning, and post-spawning migrations. 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).

Pre-spawn green sturgeon enter the Bay between late February and early May, as they migrate to spawning grounds in the Sacramento River (Heublein *et al.* 2009). Post-spawning adults may be

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

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 two to three 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.

The Bay Study is an ongoing multi-agency monitoring program managed by the CDFW that has been in operation since 1980. Each month, CDFW collects and summarizes fish catch data from mid-water and otter [bottom] trawls at defined survey points within the Bay. The CDFW also 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% 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. Adult green sturgeon, those 15 years and older, appear to use the Bay primarily as a migratory corridor to and from their spawning areas in the Sacramento River, although they may stage in San Pablo Bay on their way upstream to spawn. Studies of tagged spawning adult green sturgeon suggest individuals have rapid transit times from the Golden Gate Bridge to the Sacramento River and spend little time around SFOBB. The earliest arrival data for spawning adults was January 26th, and the latest was May 10th with a peak between February and April (David Woodbury, pers. comm. 2014). Outmigration of adults through the Golden Gate Bridge also appears to be rapid with departure times between December and February. Of 200+ tagged spawning adults, 17 (<10%) showed up at SFOBB either during immigration or emigration. Fifteen of these individuals were detected around SFOBB during an incoming tide, and then moved back north after one or two tidal cycles. Additionally, individual green sturgeon show a preference for the west span of SFOBB, opposite of YBI from Pier E3. These data suggest adult green sturgeon around SFOBB arrive there as a function of tidal currents, and then quickly move out of the area during the next tidal cycle.

Sub-adult fish (4-15 years old) typically range along the Pacific coast. They appear to move into estuaries like the Bay during periods of cold water upwelling off the coast, apparently to avoid the cold water. During these periods, sub-adults may move into the Bay in unpredictable ways. Sub-adult green sturgeon may occupy the Bay, and potentially the area around the old SFOBB bridge including Pier E3 during summer months and may remain in the area for several months (May – October). Juvenile green sturgeon move throughout the Delta and estuary during their first three to four years of life, before they move into the ocean as sub-adults. During this early life stage, they may be found in the Bay throughout the year. Between 1980 and 2012 (32 years), nine green sturgeon have been captured as part of the Bay Study throughout the entire San Francisco Bay. However, they are rare; only three individuals have been captured in Bay Study trawl data from the four sites closest to the east span of the bridge, from 1980 to 2012 (April 1998, September 1998, and May 2004). Therefore, based on the available data, NMFS believes green sturgeon could be present during the remaining SFOBB activities, including the Demonstration Project, but their abundance in the action area is expected to be very low.

2.3.2.4 Green Sturgeon Critical Habitat

The project's entire 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 area are partially 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, and periodic dredging for navigation.

2.3.3 Factors Affecting the Species Environment in the Action Area

Profound alterations to the environment of the San Francisco Bay estuary, including the action area, began with the discovery of gold in the middle of the 19th century. 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% of runoff from the Delta and upstream watersheds reach the Bay (Cloern and Jassby 2012). Water exports from the Delta increased from 5% to 30% 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% 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

San Francisco Bay is considered one of the most invaded estuaries in the world (Cohen and Carlton 1998). Invasive species contribute up to 99% 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 nonnative 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).

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 (Cloern and Jassby 2012).

2.3.3.6 Dredging and Disposal

Hydraulic dredging is a common practice within the San Francisco Bay to maintain water depths suitable for navigation for both private and commercial vessel traffic. Such dredging operations use a cutterhead dredge pulling water upwards through intake pipelines, past hydraulic pumps, and down outflow pipelines to disposal sites placing benthically-oriented fish such as green sturgeon at risk. In addition, dredging operations can re-suspend contaminants and elevate toxics such as ammonia, hydrogen sulfide, and copper and may result in impacts through changes in bathymetry (NMFS 2006). NMFS is concerned about chronic effects that may occur as a result of the uptake of contaminants by green sturgeon during juvenile rearing and during both adult and juvenile migration through the Bay. Studies on white sturgeon in estuaries indicate that the bioaccumulation of pesticides and other contaminants adversely affects growth and may result in decreased reproductive success; green sturgeon are believed to experience similar risks from contaminants (73 FR 52084).

The action area is located within a main navigation channel between the central and south San Francisco Bay, and near YBI and the Coast Guard Station at Coast Guard Cove. Therefore, this area has likely been subjected to maintenance dredging activities more frequently than other areas in the Bay in order to accommodate draft requirements for vessels. For this reason, the deep channel within the action area presumably possesses degraded habitat, due to frequent disturbance. Since all adult and juvenile CCC steelhead migrating from tributaries to the south Bay (Guadalupe River, Stevens Creek, San Francisquito Creek, Coyote Creek, Upper Penitencia Creek, Alameda Creek, and possibly San Leandro Creek [Leidy 2000]) migrate under the SFOBB, they may have experienced greater risk of exposure to dredging activities, especially if dredging was conducted during a time of year when they were migrating under the SFOBB. Similarly, some green sturgeon may pass under the SFOBB and be subject to the same risks as CCC steelhead.

2.3.3.7 Ecosystem Restoration

One of the largest ecological restoration projects undertaken in the United States has been implemented over the past decade in California's Central Valley. The CALFED Bay-Delta Program and the Central Valley Project Improvement Act's Anadromous Fish Restoration Program, in coordination with other Central Valley and Bay Area efforts, have implemented habitat restoration actions, including stream and wetland restoration projects, in close proximity to the action area. Restoration of wetland areas typically involves flooding lands previously used for agriculture, thereby creating additional wetland areas and rearing habitat for juvenile salmonids, green sturgeon, other fish species, and birds. Restoration of streams usually entails reducing erosion and sediment entry to the streams and enhancing riparian canopy and instream habitat. We anticipate these restoration projects will improve the habitat conditions for these animal species throughout the Bay, and thereby lead to potential increases in species numbers and distribution in the action area.

Additionally, Caltrans established a SFOBB East Span Seismic Project mitigation fund for the restoration of Federal-and State-listed salmonid habitat in the central and south Bay. These projects were designed to restore and enhance anadromous salmonid habitat within San Francisco Bay tributaries. Properly designed and implemented restoration actions are expected to provide significant benefits to steelhead and designated critical habitat in San Francisco Bay tributaries. Of the projects completed, only the Indigenous Oyster Habitat Project, located at the Marin Rod and Gun Club in San Pablo Bay at Point San Quentin, adjacent to the Marin County side of the Richmond-San Rafael Bridge, is thought to potentially provide similar habitat enhancements for green sturgeon. Caltrans and NMFS are currently working on an eelgrass project that may provide habitat enhancements for salmonids and green sturgeon.

2.3.4 Previous Section 7 Consultations in the Action Area

From 2000 through 2012, 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 construction of the new East Span of the Bay Bridge which has included both in-water and land-based pile driving, dredging, and construction of bridge structures. Other consultations occurring in or near the Central Bay have also occurred for sand mining, dredging, and maintenance of existing infrastructure along the shoreline (*i.e*. repair of wharves, docks and piers). For the SFOBB consultations, NMFS has determined that the associated activities were not likely to jeopardize the continued existence nor adversely modify critical habitats. For many other projects consulted on in the Bay, NMFS determined that they were not likely to adversely affect listed salmonids or green sturgeon nor 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.

2.3.5 Impacts of construction from the SFOBB East Span Seismic Project to Date

2.3.5.1 Pile Driving

Pile driving associated with the construction of the SFOBB Project has occurred intermittently since the project's inception within the action area. Both permanent and temporary piles, ranging in size and installation methods, have been installed since 2003. Monitoring requirements for the installation of the large diameter (2.5 and 1.8 m) permanent piles, primarily for piles installed for the SAS Marine Foundations E2/T1, Skyway Structure, and Oakland Approach Structure required a caged fish hydroacoustic study and monitoring program, referred to as the Fisheries and Hydroacoustic Monitoring Program.

The first phase of the monitoring project occurred during construction in November 2003 through January 2004. The second phase occurred during September 2004 through October 2004. Data from the reports show that caged fish[7] (shiner surfperch) immersed in water within the action area during pile driving suffered barotrauma effects, with 71% of the fish examined showing injuries to swim bladders and kidneys after exposure to unattenuated peak sound pressure levels (SPLs) between 207 and 209 decibels (dB) referenced to one micropascal (re: 1μ Pa) (Illingworth and Rodkin 2004). Additionally, approximately 100 fish (perch and anchovies) that floated to the surface during piscivorous bird monitoring were collected and examined. These fish exhibited severe injuries to internal organs, including ruptured swim bladders as a result of exposure to unattenuated SPLs from pile driving. The report also noted that several hundred more fish were taken by gulls. However, the study did show use of a bubble curtain for sound attenuation did in fact reduce peak SPLs, effectively reducing dB levels to 150 dB (re: 1μ Pa) at the 4,400 meter compliance criterion for the original project.

Similarly, reports submitted in 2008 for the hydroacoustic monitoring period during the installation of temporary towers D and F of the SAS also indicate fish mortality and bird predation/foraging occurrences resulting from high SPLs during unattenuated sound impact hammer pile driving activities. During the driving of the piles at Temporary Tower D, measurements were taken for the largest piles installed (42-inch diameter piles) on June 23, 2008. Piles driven with the Menck MHU 500T impact hammer were driven without any sound attenuation and resulted in the maximum peak of 217 dB peak (re: 1μ Pa) and 191 dB sound exposure level (SEL) at 20 meters north, and 206 dB peak (re: 1μ Pa) and 179 dB SEL (re: 1μ Pa^2-sec) at 135 meters north. In the initial project proposal for the SFOBB Project, Caltrans and NMFS anticipated the temporary piles required to build falsework would be substantially smaller than the permanent piles (18 to 24 inches in diameter), and therefore SPLs would be lower and not at levels injurious to fish. However, changes to the project during the course of various planning phases resulted in plans consisting of more temporary piles than anticipated, and piles twice as large as what was originally proposed (42 to 48-inch diameter piles). Unfortunately this increase in number and size did not result in any sound attenuation methods being developed for the piles. Therefore, sound attenuation was not incorporated for the installation of in-water

7 The caged fish monitoring study originally included the use of caged steelhead from the CDFG Nimbus hatchery. However due to excessive mortalities (95%) within the steelhead treatment groups, steelhead could not be included in analyses for the study.

temporary piles required for falsework necessary to construct the Marine Foundations E2/T1, Skyway Structure, Oakland Approach Structure and the temporary towers (D, F, and G) for the SAS.

Fish kills have been documented as occurring as a result of pile driving within the action area in 2008 and 2009 (Garcia and Associates 2008, 2009). Although no records of listed salmonids or green sturgeon have been reported by Caltrans, there have been observations of mortality, incapacitation and stunning of other fish species during monitoring activities concurrent with pile driving. Given that many of these fish are forage species, these incidents of impacts effectively degraded anadromous fish habitat quality within the action area by decreasing the availability of food resources as well as exposing salmonids and green sturgeon to increased risk of injury as a result of high SPLs. Moreover, since monitoring of pile driving activities occurred for only 10 percent of the time, the possibility exists of unrecorded impacts to listed anadromous fish. Additionally, some temporary piles were driven during peak salmonid migration periods (December through May).

The piles installed for temporary falsework needed to construct Temporary Tower G at YBI were driven into place between March 4, 2009 and May 15, 2009. As described in the April 10, 2009, supplemental biological opinion, NMFS developed a reasonable worst case scenario for the effects of this pile driving for temporary falsework at YBI on listed salmonids and green sturgeon. In summary, that reasonable worst case scenario assumed: 1) twenty-five percent of the CCC steelhead population migrate to the east side of YBI en route to and from the Golden Gate; 2) juvenile, subadult and non-spawning adult green sturgeon could be present in the action area year-round; 3) roughly two percent of adult green sturgeon spawners could be present in the action area February through May; 4) remaining pile driving will occur in areas greater than five meters deep during peak migration periods for spawning CCC adult steelhead (February through May), and for spawning adult green sturgeon (February through May); 5) a maximum of three piles will be installed per day (with an impact hammer) intermittently over the course of four months; and 6) some pile installation will occur at night. The 4982 m diameter of the impact area corresponding to the 206 peak dB and 187 SEL during that phase of construction was the greatest distance considered due to the maximum peak dB level obtained from initial hydroacoustic measurements during the construction of Temporary Tower D.

With the assumptions described above, we expected roughly two percent of the outmigrating juvenile and post-spawned adult population of steelhead originating from south San Francisco Bay tributaries were likely to be injured or killed by sound pressure levels exceeding 206 dB (re: 1 μPa), 187 SEL (re: 1 μPa^2-sec) during the remaining pile driving in 2009. We also estimated that a small number of juvenile, subadult, and adult spawning green sturgeon were likely to be injured or killed by these sound pressure levels. Results from Caltrans' hydroacoustic and biological monitoring indicate that the maximum sound pressure levels expected did not extend beyond the area of impact analyzed in the April 10, 2009, biological opinion during pile driving for temporary falsework at YBI. However, additional fish kills did occur (*e.g.*, pacific herring [Clupea pallasii]) as documented in the reports submitted for hydroacoustic and biological monitoring, taken during the installation of Temporary Tower G between March 4 and May 19, 2009. Hydroacoustic measurements taken during the installation of the 42 and 48-inch diameter piles indicate that SPLs ranged from 166-223 peak dB (re: 1 μPa), at both deep and shallow water sensors out from 500 m in to 14 m distances from the piles.

Accumulated SELs ranged between 176 -226 dB (re: 1µ Pa2-sec) at distances out from 560 m in to 17 m, respectively. On July 23, 2009, NMFS received notification from Caltrans that during impact hammer pile driving on May 7, 2009, pacific herring were killed, and the biological monitoring reports submitted for other monitored pile driving events document several other bird predation events. However, as with the installation of Temporary Towers D and F, Caltrans' biologists did not see any injury or mortality for ESA-listed fish species. Based on this information, and the lack of anadromous dead fish sighted by Caltrans' biological monitors during this pile driving, NMFS assumes the losses of listed species during this pile driving were as described in the April 10, 2009, BO. Incidental take in the form of fish death or injury was expected for no more than two percent adult and juvenile CCC steelhead originating from the south San Francisco Bay tributaries, and adult spawning green sturgeon, and for only a very small number of juvenile, subadult and non-spawning adult green sturgeon during the remaining years of construction.

Similarly, during the installation of twenty-two 36-inch diameter steel piles for the construction of the T1 Temporary Access Trestle for the SAS, the biological monitors observed a small amount of bird strikes during one pile driving event. However, no ESA-listed fish were observed. Although there were some problems encountered with implementation of the bubble curtain (likely due to slope and substrate), due to the timing and short duration of this pile driving event and location, and no observed injuries or mortality of ESA-listed fish species in the action area, NMFS assumes that any losses that may have occurred were as described in the August 21, 2009 BO.

With all of the information obtained regarding the effects from pile driving to fish between 2003 and 2014, vast improvements have been made by the acoustics and construction industries regarding sound attenuation and the ability to predict areas impacted by sound traveling through the water column. Additionally, there are areas in the action area which are known to have hardened substrate types and have been shown to cause higher levels of sound during pile driving with an impact hammer, thus sound propagation models can now, to some extent take into consideration the varying substrate types. Because of this, all pile driving events since 2009 have not resulted in any type of observed fish kill. Bird predation events, which are indicative of fish kills, were also not observed.

The February 2012 BO analyzed the effects of pile installation and pile "proofing" required to construct the trestles and falsework needed for bridge removal work. A total of 2,540 piles were anticipated to be needed, ranging in size and type from 14-inch H-piles to 18-36-inch diameter steel pipe piles. Temporary falsework construction has occurred each construction season from 2012 through 2014. Both vibratory and impact hammers have been used to install piles. All piles driven with an impact hammer have had sound monitoring conducted to insure sound levels were within the expected ranges. To date, only 310 piles out of the 2,540 have been installed. Out of 33 pile driving events, some minor exceedences of the sound pressure thresholds occurred. The peak and cSEL thresholds were exceeded seven times, two times in February 2014, and five times in August through September 2014 during installation of the largest 36-inch steel pipe piles. The affected areas were close to the shoreline, and no ESA-listed fish were thought by NMFS to be present in these areas. Eight exceedences of sound pressure thresholds did not reach injurious levels, but did exceed the 150 dB RMS threshold which corresponds with fish behavior. Exceedence of this threshold occurred during some of the same days that the injurious thresholds were exceeded above, and in September 2012, October 2013 and March 2014. However, no fish kills nor bird predation events were observed during any of these days, therefore NMFS does not believe any take of ESA-listed species has occurred beyond what has been exempted during pile driving events between 2012-2014. Moreover, because of the overall decrease in the amount of pile driving that was expected to occur between 2009-2014, take of ESA-listed species could be less than what was exempted.

The 2012 BO also recalculated the amount of incidental take based upon the 2009 BO worst case scenario described above, however, adjustments were made based upon changes to the pile driving activities remaining. For example, pile proofing in winter, December through May, would mean that Central Valley spring-run Chinook salmon, Central Valley winter-run Chinook salmon, and Central Valley steelhead were also likely to be adversely affected, albeit in very low numbers. A maximum of two piles would be proofed per day (with an impact hammer) intermittently over the course of four months, and some pile installation was to occur at night in the summer and fall months (June through November). The 3981 m radial distance of the impact area corresponding to the 150 dB RMS was the greatest distance considered for the entire demolition phase due to the data taken from hydroacoustic measures during the construction of this project and others. With these assumptions, roughly .0003 percent of the outmigrating juvenile and post-spawned adult population of CCC steelhead originating from south San Francisco Bay tributaries were thought to be injured, killed, or harassed by sound pressure levels exceeding 206 dB (re: 1 μPa), 187 SEL dB (re: 1 μPa 2-sec), or 150 dB RMS (re: 1 μPa) during the remaining pile driving over 5 winter-spring seasons (2013-2017). The .0003 percentage of steelhead was determined based upon the following assumptions, that approximately 25 percent of the south Bay CCC steelhead population are estimated to transit east of YBI through the action area, and two piles will be proofed with an impact hammer within a given 24 hour period for only a two minute duration during the entire migration season (December 1st to May 31st). The worst case scenario then, was that all pile proofing would occur during migration seasons, for two minutes per day annually during the six months which equates to approximately .001 percent of time. Far fewer of the Central Valley salmonids were likely to be harassed, injured, or killed due to the distance between the sound pressure impact area and the main migration routes of these species.

2.3.5.2 Dredging and Disposal

All dredging and disposal to the SF-11 disposal site is complete. The amount of dredging and disposal that has occurred for this project has been substantially less than what was described and analyzed in the February 2012 BO. Based on this information, NMFS expects the effects of dredging and disposal were no greater than the effects analyzed in the 2012 BO (and were likely less).

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 CV spring-run Chinook, Sacramento winter-run Chinook, CV steelhead, CCC steelhead and southern DPS green sturgeon; and their respective designated critical habitat. 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 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 green sturgeon, and their critical habitat, were limited or not available, our assessment of effects focused mostly on qualitative identification of likely stressors and responses.

The SFOBB Seismic Safety Project and associated Demonstration Project's effects are expected to result in adverse effects to listed salmonids and green sturgeon, and their respective critical habitats. Once the old bridge removal is complete, no adverse effects are expected to occur as a result of this project. The analyses of impacts on salmonids and green sturgeon from prior construction activities are reported above in the Environmental Baseline, and the effects of the remaining construction activities are included below and in our integration and synthesis of effects.

2.4.1. Effects from Pile Driving.

The remaining pile driving activities for the SFOBB East Span Seismic Safety Project are expected to result in adverse effects to listed salmonids, primarily CCC steelhead, and southern DPS green sturgeon, and their respective critical habitats. For the three listed salmonid ESUs originating from the Central Valley (Central Valley steelhead, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon), NMFS expects that adult fish generally remain on the north side of San Francisco Bay after entering the estuary through the Golden Gate, migrating rapidly around Angel Island and through San Pablo Bay towards the Delta and their natal Central Valley streams. Although a few adult salmon have been recorded feeding near YBI in the summer, the number of adults that uses this area is likely small. For salmonid smolts originating from Central Valley streams, it is generally thought that they, too, utilize the north side of the Bay as their primary migration corridor (MacFarlane and Norton 2002, Jahn 2004).

2.4.2. Effects from Implosion of Pier E3.

November was identified by NMFS and CDFW as the preferred time for the Pier E3 implosion because listed fish are less likely to be present around Pier E3 based on their life histories and migration times. The monthly distributional data derived from the Bay Study support this conclusion. Data from the Bay Study were also used to calculate November monthly densities for protected fish species and seasonal distribution of fish species in the vicinity of Pier E3. Caltrans analyzed the Bay Study data collected from 1980 to 2012 for sample site 110, located approximately 1.8 miles south of Pier E3. Monthly population densities were averaged for the entire 32 year data set to identify optimal times to complete the Demonstration Project. To evaluate potential impacts from the Pier E3 controlled implosion, November density data for NMFS' jurisdictional species in the action area were calculated by averaging the Bay Study catch data collected in mid-water or otter trawl over the last five years (2008 – 2012) located at survey points around Pier E3. The number of fish captured was divided by the volume sampled in each survey point, which was then extrapolated to the volume of the area of interest (*e.g.*, action area) and compared against each month activities could occur for the project. Additionally, as a comparison against the number of potentially affected individuals within the portion of the action area affected by the Demonstration Project (sound field), to an estimate of the larger November Central/South Bay population was calculated by using this method to apply polygon-specific densities based on the catch data survey points within the action area affected by sound pressure waves during the controlled blast. The polygons are an overlay of the sample sites with specific fish densities per month to the sound field. After doing this for every month of the last five years, November showed the lowest density of fish throughout the action area (Figure 8).

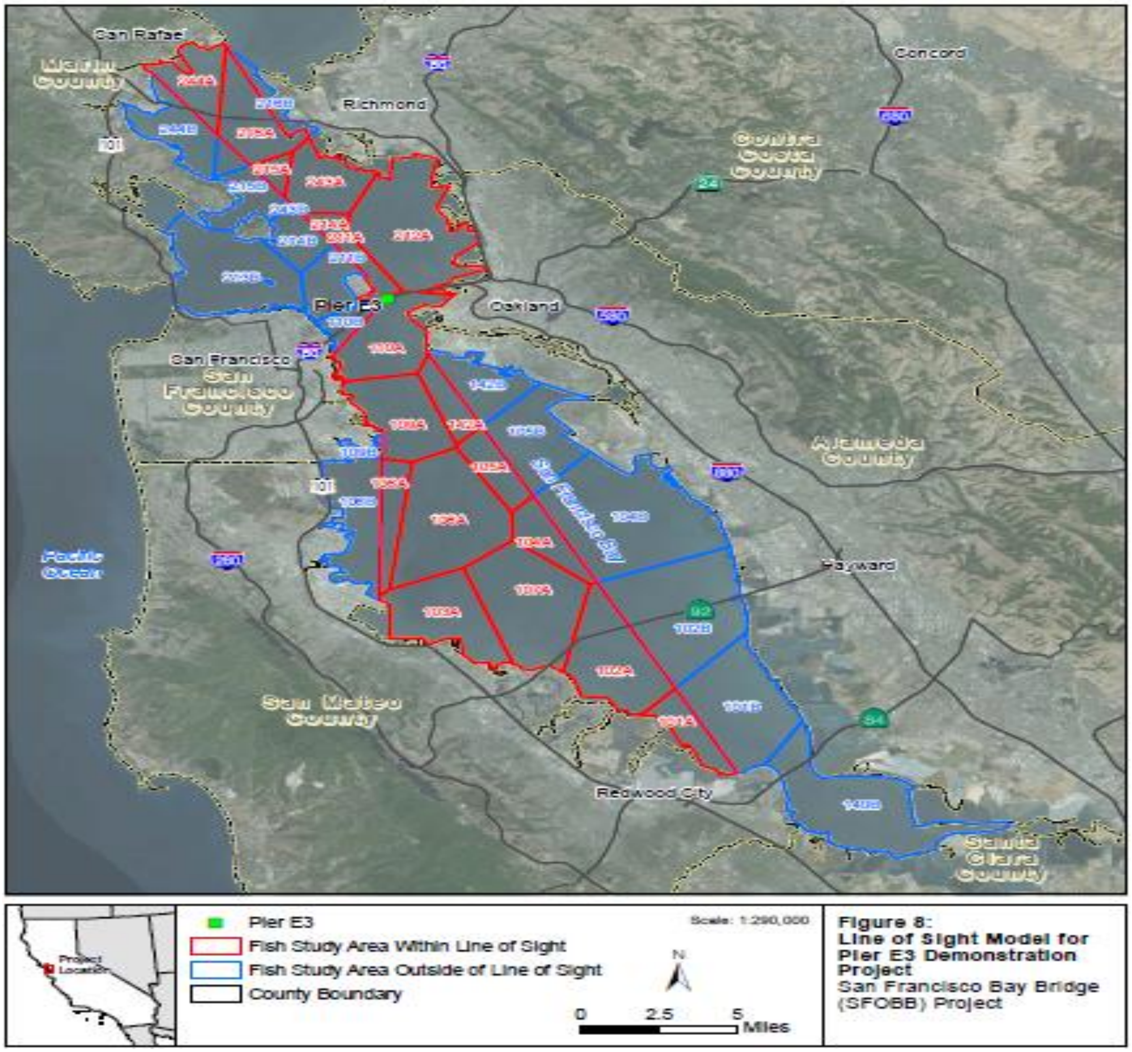

Figure 8. Polygon transects of fish density for the month of November

2.4.3 Effects of Underwater Sound Pressure on Fish.

Fish may be injured or killed when exposed to high levels of underwater sound, especially those generated by impulsive sound sources such as pile driving with impact hammers, airguns, and underwater blasts. Pathologies of fish associated with very high sound level exposure and drastic changes in pressure are collectively known as barotraumas. Barotraumas range from non-lethal to lethal depending on explosion characteristics. Lethal injuries include hemorrhage and rupture of blood vessels and internal organs, including the swim bladder and kidneys. Death can be instantaneous, occur within minutes after exposure, or occur several days later. Gisiner (1998) reports swim bladders of fish can perforate and hemorrhage when exposed to blast and high-energy impulse noise underwater. If the swim bladder bursts and the air escapes from the body cavity or is forced out of the pneumatic duct, the fish may sink to the bottom. If the swim bladder bursts but the air stays inside the body cavity, the fish is likely to stay afloat but have some difficulty in maneuvering or maintaining position and orientation in the water column. Non-lethal barotrauma may result in altered physiological states, including changes in scale loss, hormone levels, sensory detection, tissue damage, embolisms, and possible changes in behaviors that increase the fish's risk of exposure to predation (Linton *et al.* 1985; Popper *et al.* 2004; Scheer *et al.* 2009) or other decreased fitness consequence.

As described above, sound pressure waves can pass through a fish's body and cause the swim bladder to routinely expand and contract with the fluctuating sound pressures. At high sound pressure level exposure, the swim bladder may rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in the rupture of capillaries in the internal organs as indicated by observed blood in the abdominal cavity, and maceration of the kidney tissues, as the internal organs are bound by the vertebral column above and the muscles and skin of the abdominal cavity and cannot move out of the way (Gaspin 1975). With pile driving, the underwater sound pressure waves that have the potential to adversely affect listed anadromous fish species originate with the contact of the hammer with the top of the steel pile. The impact of the hammer on the top of the steel pile causes a wave to travel down the pile and causes the pile to resonate radially and longitudinally like a gigantic bell. Most of the acoustic energy is a result of the outward expansion and inward contraction of the walls of the steel pipe pile as the compression wave moves down the pile from the hammer to the end of the pile buried in the bay bottom. Water is virtually incompressible and the outward movement of the pipe pile (by a fraction of an inch) followed by the pile walls pulling back inward to their original shape, sends an underwater pressure wave propagating outward from the pile in all directions. The steel pipe pile resonates sending out a succession of waves even as it is pushed several inches deeper into the bay bottom. For underwater blasts, due to the vast diversity of fishes and inconsistencies or variations among fish species, it is difficult to characterize the effects of underwater blasts on fish in a generic manner. However, with experimental designs and blast-related data, four parameters have been identified as the most likely strong predictors of fish mortality from exposure to underwater blasts. These are pressure, impulse, energy density, and detonation velocity (the detonation rate of blasting agents). As with pile driving sound exposure, the severity of injury on fish from exposure to underwater blasts likely depends on fish species, size of the charge and distance from the detonation (Wiley *et al.* 1981). Other confounding factors, such as water depth and substrate types will affect the characteristics of the sound pressure wave and how it propagates from the source.

Studies conducted during underwater rock blasts have documented the swim bladder of fish to be most often the injured organ to varying degrees (Wiley *et al*. 1981; Linton *et al*. 1985; Yelverton *et al*. 1975). In addition, Svedrup *et al.* (1994) exposed Atlantic salmon to detonating blasting caps, which simulated the blast from a seismic survey. The vascular endothelium (the cells that line the circulatory system) showed signs of injury within 30 minutes of exposure, as compared to control specimens that did not show these effects. The fish recovered from their injuries within one week. In another study, the pressure-related mortality of fish has been documented as a result of underwater rock blasts (Wiley *et al.* 1981), but the exact measurement (waveform) to predict pressure-related mortality is poorly documented. The rapid change between high overpressures and high underpressures is likely the primary factor for fish mortality. This change or series of rapid changes results in the rapid contraction and overextension of the swim bladders that subsequently leads to internal organ displacement and damage, and ultimately mortality. During rapid pressure changes, gases in solution in the fish's body may form emboli (gas bubbles), which can lodge in vital organs such as the heart, brain, and kidneys, resulting in mortality.

Differences in fish sensitivity to acoustic pressure is also the result of the presence and type of swim bladder, as well as proximity and linkage of the swim bladder to the ear. Fishes with swim bladders are far more sensitive to sound, and therefore more susceptible to injury from underwater sound exposure, than are fishes that lack swim bladders. The type, proximity and connection of the swim bladder to the ear in fishes will determine the degree of sensitivity (Popper *et al.* 2003; Braun and Grande 2008). The air within the swim bladder is a much lower density than that of water and the fish's body. Thus the air (and swim bladder), can easily be compressed by sound pressure waves traveling through the fish's body. Compression of the air causes the volume of the swim bladder to cyclically change (reverberate) in reaction to fluctuating sound pressure waves. Therefore, movements of the swim bladder wall (particle motion) are transmitted to, and stimulate, the inner ear.

There are two types of swim bladders, physotomous and physoclistous. Fish with physostomous swim bladders retain connection between the pneumatic duct and the intestinal tract. This allows the fish to fill up the swim bladder by "gulping" air and can remove or expel gas in a similar manner by dumping it into the gut and "burping". This condition is typical of more primitive bony fishes such as salmon, sturgeon, and herrings. Because physostomes can regulate the air in their body through gulping or burping out air, they may be able to expel air more rapidly in response to sound exposure. This may be a factor that influences the degree of injury they sustain from exposure high sound pressure levels. For example, a deflated swim bladder (negatively buoyant) could put the fish at a lower risk of injury from the sound exposure compared to a fish with an inflated swim bladder (positively buoyant). Both salmonids and green sturgeon possess a physostomous swimbladder. However, since there is no way to know the buoyancy state of the fish during exposure to the implosion, NMFS will assume the worst case scenario that the swim bladders are positively buoyant, and therefore, exposed fish could be subjected to the highest degree of trauma.

In 2004, NMFS, FHWA and Caltrans formed the Fisheries Hydroacoustic Working Group (FHWG) to address the issue of potential impacts to listed species from exposure to underwater sounds produced by anthropogenic sound sources, especially pile driving. As a result of this, Caltrans contracted with prominent experts in the field of underwater acoustics to review existing literature and conduct research on the effects of underwater sound on fish (Hastings and Popper 2005, Popper 2006). At a FHWG meeting in Vancouver, Washington in June 2008, an Agreement in Principle between NMFS, Caltrans and others was reached regarding the establishment of interim thresholds to be used to assess physical injury to fish exposed to underwater sound produced during pile driving. Specifically, this included a single strike peak sound pressure level (SPL) of 206 dB (re: 1 μPa) and an accumulated sound exposure level (cSEL) of 187 dB (re: 1 μPa 2-sec) for fish greater than two grams or 183 dB (re: 1 μPa^2-sec) for fish less than two grams. The decision to include the SEL metric along with peak dB SPL metric was based upon the primary rationale that this SEL metric provided a way to sum the energy over multiple impulses, which cannot be accomplished with peak pressure. Using SEL, the exposure of fish to a total amount of energy (*i.e.* dose) can be used to determine a physical injury response. If either threshold is exceeded, then physical injury is assumed to occur. There is uncertainty as to the behavioral response of fish to high levels of underwater sound. Based on the information currently available, and until new data indicate otherwise, NMFS believes a 150 dB root-mean-square pressure (RMS) threshold for behavioral responses for fish with swim bladders (*e.g.*, salmonids and green sturgeon) is appropriate.

Pile Driving. NMFS analyzed the effects of pile driving (and removal) for the remaining trestles and falsework necessary for bridge demolition in the February 2012 BO, including the avoidance and minimization measures. As a result, NMFS does not anticipate SPLs, SELs and RMS threshold values to be exceeded beyond the following distances surrounding each pile during each construction phase, for fish greater than or equal to two grams:

For attenuated piles (using an air bubble curtain, or other device), 206 dB peak SPL at 1 m (2 m diameter), 187 dB accumulated SEL at 34 m (68 m diameter), and 150 dB RMS at 398 m (796 m diameter);

For proofed piles, 206 dB peak SPL at 7 m (14 m diameter), 187 dB accumulated SEL at 19 m (38 m diameter), and 150 dB RMS at 3981 m (7962 m diameter);

For the steel H-piles, 206 dB peak SPL at 10 m (radial distance), 187 dB accumulated SEL at 65 m (radial distance), and 150 dB RMS at 1311 m.

As distance from the pile increases, sound pressure levels decrease and the potential harmful effects to fish also decrease. Hence the distance to reach the 150 dB RMS corresponding to subinjurious sound levels (*i.e*., non-lethal, behavioral responses), is not expected to extend beyond a 3981 m radius from the east span of the bridge for any pile driving event. This larger area defines the total area of impact expected from pile driving during bridge dismantling activities.

We made estimates based upon the largest pile size and type we anticipated for this project, during attenuated and unattenuated impact hammer pile driving, 36-inch steel pipe piles and 14-inch steel H-piles. Our reasoning assumes installing the largest piles with the same number of strikes as the smaller piles will result in the largest area expected to have sound pressure impacts during any pile driving scenario. Using the attenuated (assuming 10 dB reduction) reference values of 189 dB peak (re: 1 μPa), 160 dB SEL (re: 1 μPa^2-sec) and 174 dB RMS measured at 10 meters, and estimating a total of 3160 strikes per day (158 strikes per pile, 20 piles maximum) with a transmission loss (TL) of 15 dB; results in the distance to reach the injury and sub-injury thresholds provided above for attenuated impact hammer installation of the piles. For installation of the H-piles, Caltrans assumes a higher TL of 17 dB, due to site specific conditions. However, since Caltrans will need to also proof a small subset of the piles (10%) with an impact hammer, the largest area of impact is based upon the unattenuated RMS threshold distance of 3981 m (7962 diameter) for the 36-inch piles.

During summer and fall months, the project's pile driving activities occurring from June 1st through November 30th for the temporary structures are not expected to result in adverse effects to listed steelhead because no life stage is expected to be present during construction between June 1st and November 30th. Additionally, during this time, the project's pile driving activities are not expected to result in impacts to adult spawning green sturgeon. However, juvenile

Chinook salmon and juvenile, sub-adult, and some non-spawning adult green sturgeon have the potential to be within the action area during pile driving. The incorporation of a bubble curtain during this timeframe, when impact hammer pile driving occurs is expected to reduce the area where injury may occur, and also reduce the area where sub-injury is possible. Another concern is that any pile driving that occurs after dusk during the summer and fall months, could overlap with the period when the majority of downstream salmonid movement occurs. Quinn (2005) indicates that salmonids generally move downstream at night. Shapovalov and Taft (1954) report that emigrating juvenile steelhead move downstream at all hours of the day and night, but the bulk of downstream fish movement occurs during the night or at least in the early morning or late evening. Because they share other migration similarities with salmonids, such as outmigrating through the estuary in the spring months, green sturgeon may possess a similar behavior. Artificial lights that are used on the pile driving platforms after dark may also attract fish to the immediate vicinity of the operation and into the area of lethal sound pressure levels. Although juvenile green sturgeon swimming behaviors encountered within the estuary is not clear, research by Van Eenennaam et al. (2001) indicates that juvenile green sturgeon exhibit nocturnal activity patterns in freshwater whereby they move higher into the water column at night. If this same type of nocturnal behavior occurs in the estuary, their vulnerability to pile driving impacts could increase at night. However, the majority of the remaining pile driving activities for the project are not expected to occur at night, and if night work is necessary it will be restricted to the period of June 1st through November 30th, and Caltrans will direct illumination away from the water. NMFS expects harassment, injury, or loss of juvenile Chinook salmon or green sturgeon to be very small because of the timing (mostly during the day), small radius (68 m maximum) of sound pressure waves from pile driving, and small numbers of these species likely present.

During the winter and spring months, pile proofing may occur, which has the potential to affect migrating salmonids (primarily CCC steelhead, but also CV steelhead, CV winter-run Chinook salmon and CV spring-run Chinook salmon), from December 1st through May 31st, and green sturgeon. However, the duration for pile proofing during peak (February-May) migration periods is expected to occur for no more than two minutes a day, thus the area of impact where injury may occur in any given pile proofing scenario is only expected to be a 19 m radial (38 m diameter) distance. From 19 m to a radius of 3981 m (7962 m diameter) we expect sub-injurious effects may occur. Although this is a seemingly large area during peak migration times, the limited duration (two minutes per day) is not expected to substantially alter migration behavior.

Sound pressure levels extending out to this distance would only reach to the north, south and east of the pile driving area as YBI blocks the area to the west. Additionally, the area within 3981 m radius from the pile during proofing is predominantly located in deeper waters in the Bay where currents are stronger and fish are expected to quickly transit through during migration. No more than 244 piles total were to be proofed in this manner over the duration of this project phase (2012-2017), and an even smaller subset of those would be proofed during winter and spring months. In 2012 we anticipated, given the short duration of each proofing event, nearly all of salmonid and green sturgeon migration periods will be free from disturbances resulting from pile proofing. Moreover, we expected any migrating fish that may be disturbed but not injured during a pile proofing event would quickly return to normal behavior patterns once pile driving ceases. No lasting adverse effects are likely for nearly all migrating salmonids and green sturgeon mainly due to their larger bodies (above two grams), and because pile driving activities will occur only in the daytime during migration season which would avoid crepuscular and nocturnal periods when salmonid and sturgeon migratory activity is likely the highest.

As described above in the Proposed Action (Section 1.3), Caltrans had made modifications to the project construction activities since the 2012 BO, and has not used the vast majority of piles originally anticipated. Additionally, Caltrans believes that future work during the remaining dismantling activities will not require nearly as many piles for falsework and trestle construction because sections of the old bridge can now be removed and loaded onto barges, rather than onto trucks. This means an overall reduction in support structures will be required for trucks, etc. Moreover, if Caltrans installs the majority of any remaining temporary piles with a vibratory hammer, and only uses an impact hammer for minimal re-taps and pile proofing, the remaining pile driving activities are not anticipated to result in substantial incidence of physical injury or mortality to fish; and our reasonable worst case scenario described in the 2012 BO is unlikely to be realized. Nevertheless, a very small number of listed salmonids, primarily CCC steelhead, may be adversely affected by pile proofing activities. Fish so affected would be harassed, injured, or killed.

Implosion of Pier E3. At the time these impulsive sound thresholds were established, the available information was limited to different types of impulsive sound sources, including underwater explosions and seismic airgun blasts. Because of this, NMFS has determined that the current FHWG thresholds for impulsive sounds produced during pile driving are suitable metrics to use for the analyses of potential effects to fish exposed to controlled blasts, since the thresholds for pile driving are based on the similar impulsive sound type produced by underwater blasts. Using this rationale, Caltrans calculated the distances to reach the respective thresholds from Pier E3 during the implosion event. For ESA-listed fish species, this results in a potential impact area where onset of injury to fish could occur within a 470 acre area, corresponding to the following threshold distances: 206 dB peak at 245 meters (820 feet), and 187 dB cSEL at 777 meters (2,550 feet). The area of impact during detonation of the test charge a few days prior to the controlled implosion will be much smaller than the area of the implosion itself. Since the test blast will be a single-impulse detonation, the cSEL metric is not an appropriate metric to apply. The area where onset of injury may occur then corresponds to the instantaneous change in pressure corresponding to the 206 dB peak threshold, which would reach a radial distance of 27 meters (88 feet) from Pier E3. No ESA-listed fish species less than two grams are expected to be present, therefore only the distance to reach the 187 dB cSEL threshold represents the entire area where fish may be injured or killed if located within that zone surrounding Pier E3 during the implosion event. However, because of the timing of the implosion in November, site conditions, and duration (four to six seconds) of the blast, listed salmonids are unlikely to be present. Green sturgeon are likely to be present, but only in very low numbers, thus very few fish are expected to be subjected to injurious sound pressure levels produced during the implosion or test blast.

2.4.4 Behavioral Effects of Sound Exposure on Fishes

Underwater sounds have also been shown to alter the behavior of fishes (see review by Hastings and Popper 2005). The observed behavioral changes include startle responses and increases in stress hormones. Other potential changes include reduced predator awareness and reduced feeding. The potential for adverse behavioral effects will depend 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.

Exposure to human-made sound may also result in "agitation" of fishes indicated by a change in swimming behavior detected by Shin (1995) with salmonids, or "alarm" detected by Fewtrell *et al.* (2003). Startle responses may also be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators (Popper 1997). A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus.

As mentioned above, NMFS believes a 150 dB RMS threshold for impulsive sound sources is the appropriate metric to determine the potential range where sub-injury (*i.e.*, behavioral) may occur on fish. For pile driving, this would occur at a distance 398 m from the pile during attenuated impact hammering of 36-inch piles, and at a 3981 m distance during unattenuated pile proofing, and a 1311 m distance during impact hammering the H-piles. NMFS estimates fish greater than two grams will be agitated or disturbed, but survive exposure to SPLs and not sustain permanent harm or injury.

During the implosion of Pier E3, Caltrans estimates the total area where fish may exhibit a behavioral response during the controlled implosion to encompass an area of approximately 56,011 acres, corresponding to the distance to reach the 150 dB RMS radius of 220,726 meters (68,000 feet) from Pier E3. For the test charge, Caltrans estimates the distance to reach the 150 dB RMS threshold to be 4,000 feet (1,219 meters) from Pier E3. NMFS assumes fish greater than two grams located within this area during the implosion may detect the sound pressure and will be agitated or disturbed, but survive exposure to SPLs and not sustain permanent harm or injury. These fish may demonstrate temporary abnormal behavior indicative of stress or exhibit a startle response. As described previously, a fish that exhibits a startle response is typically not injured, nor is its fitness likely to be reduced, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. Because the duration of the sound pressure wave will be no longer than six seconds, if a fish perceives the sound in that very short timeframe, any startle responses fish exhibit are likely to extinguish quickly, without injury, after the detonation.

2.4.5. Effects to Listed Species from Otter Trawling

As part of the required CDFW monitoring, Caltrans will conduct otter trawls immediately after the implosion of Pier E3. The area that will be trawled extends from the 183 cSEL radial distance in towards Pier E3. This area extends beyond the range of injury for green sturgeon (and salmonids) since CDFW is concerned with impacts to longfin smelt and other fish species two grams or smaller in size. Due to this change in the area, a very small number of green sturgeon could be captured during the trawl and would be subjected to injury and handling stress alone, independent of the implosion itself. Based on the timing (November), short duration, and location (near pier E3), NMFS does not anticipate any salmonids will be captured by otter trawling.

NMFS used the Bay Study to estimate the number of green sturgeon that may be captured and injured or killed by otter trawling. In November, when the otter trawling will occur, no green sturgeon were captured in the Bay Study. However, green sturgeon are likely present in the Bay all year. NMFS assumes the lack of Bay Study catch in November for 32 years indicates lower numbers present in the action area during this month. The Bay Study is a sample of fish in the Bay (not a census) and species with low numbers could easily be missed given the large volume of Bay water and small areas and short time frames covered by Bay Study catch efforts. NMFS therefore conservatively estimates no more than three green sturgeon would be captured in the otter trawl nets. This number is likely an overestimate and can be verified since actual fish counts will be conducted of fish captured in the nets.

Green sturgeon are encountered as bycatch in fisheries along the West Coast, including the some trawl fisheries. However, the impact to the species from being captured is difficult to understand given the lack of information on the effects of catch and release on green sturgeon in these fisheries. NMFS is currently researching this issue to better understand post-release survival of green sturgeon incidentally caught in the California halibut fishery. Until this data becomes available, NMFS assumes green sturgeon caught in the otter trawl could be injured and potentially killed from being dragged from the Bay substrate and up through the water column in the trawl nets. Moreover, if any green sturgeon are present in the potential blast injury zones (206 dB peak at 245 meters, and 187 dB cSEL at 777 meters) they could also be collected in the nets. If green sturgeon do not sustain mortal injuries form the blast, they could be temporarily stunned or disoriented. In some situations these fish could recover from their injuries sometime later, and just swim away from the implosion area. However, this temporary disorientation or reduced reaction time from survivable injury would make them more susceptible to capture during the trawl. Therefore, these fish would be subjected to additional stress and increased survival risks from handling and processing as a result of the otter trawl sampling, which could compound any injury or effects from the blast exposure.

2.4.6 Effects to Listed Species from Changes in Water Quality

The proposed action may affect listed salmonids and green sturgeon through elevated levels of turbidity, or total suspended and dissolved solids in the water, pH, dissolved oxygen, and sediment-associated contaminants in the water column. However, based on Caltran's water quality evaluation completed to date, the Demonstration Project would result in minimal impacts to water quality parameters affected by turbidity, pH, contaminants, and dissolved oxygen. Thus impacts to water quality will be temporary in duration, expected to completely dissipate within 90 – 120 minutes post-implosion due to tidal currents and mixing. No permanent impacts to water quality are anticipated. Water quality monitoring would be conducted for any condition where debris, sediment, or other pollutants have the potential to be introduced into Bay waters and be dispersed or transported with currents away from the work area. The impacts to water quality are discussed in greater detail below.

Potential Impacts from Caisson Water. In October 2014, water and sediment samples were collected from the Pier E3 caisson. Details of the sampling and analytical methods, including quality control procedures, used to investigate the caisson water quality were provided in Pier E3 Caisson Water Quality technical memorandum (AMEC Foster Wheeler 2015). Conductivity, pH, temperature, turbidity and dissolved oxygen were measured at regular intervals from the water surface to the bottom of the caisson and discrete water samples were collected at three depths. Two samples of ambient Bay water were also collected from the southeast and northeast corners of a barge near the Demonstration Project area, referenced as SE Barge and NE Barge. As a result of this sampling, Caltrans determined the majority of the water within Pier E3's caisson resembles the ambient water quality of San Francisco Bay, with some exceptions in the uppermost and deepest strata (Caltrans 2015b). Since the implosion plan intends for the deepest layers of the caisson to be contained and subsequently buried with concrete rubble and eventually filling in of Bay substrate, those deeper layer areas are not expected to become exposed or mix with the surrounding Bay water column. These areas will be contained well below the mudline.

However, the implosion is anticipated to temporarily elevate pH inside Pier E3 due to the mixing of large concrete particles with caisson water. In addition, a potential pH spike of greater than 0.5 units above ambient may occur within 100 feet of Pier E3. This spike, similar to the turbidity plume (see discussion below), would be dispersed within 90 to 120 minutes of the implosion. Disposing of concrete rubble within Pier E3 during mechanical dismantling of the pier cap would displace an equal volume of caisson water (*i.e.*, every cubic yard of concrete disposed would displace a cubic yard of caisson water). Due to the presence of weep holes in the caisson walls at -5 feet that allow free exchange of caisson water with the Bay, concrete disposal could displace caisson water with low dissolved oxygen, metals, and high pH to the Bay. For these reasons, several strategies for the management of caisson water have been identified. Caltrans will manage the surficial 10-foot layer of water inside the caisson cells (approximately 250,000 gallons total) with depressed dissolved oxygen concentrations to avoid displacement into the Bay during concrete disposal activities. Once exposed to the atmosphere it's likely that dissolved oxygen concentrations in this surficial layer will increase naturally. To accelerate this process, Caltrans proposes to inject compressed ambient air into the caisson cells to increase dissolved oxygen concentrations in situ. Aerating caisson water would require the use of pumps and hoses to elevate dissolved oxygen concentrations to reach the water quality objectives of 5 mg/L prior to discharge. However, this aeration will not likely have an effect on potentially elevated pH within the caisson cells, so water quality monitoring would be performed during these activities to evaluate actual impacts. Water quality monitors would have the authority to stop work should target water quality parameters be exceeded. Caltrans will address any water quality issues before proceeding with the implosion. For example, dewatering and hauling off the caisson water is a possibility.

Turbidity from Pile Driving and Pile Removal. Pile driving and removal of the temporary falsework is expected to create temporary increases in turbidity in the adjacent water column. These minor and localized elevated levels of turbidity will quickly disperse from the project area with tidal circulation. Listed anadromous salmonids and green sturgeon in the San Francisco Bay estuary commonly encounter, and typically avoid, areas of increased turbidity due to storm flow runoff events, wind and wave action, and benthic foraging activities of other aquatic organisms. Therefore, the minor and localized areas of turbidity associated with this project's in-water pile driving and removal of temporary piles is not expected to impair or harm listed salmonids or green sturgeon and will not result in long-term impacts to aquatic habitat.

Turbidity from Implosion of Pier E3. Elevated levels of turbidity will occur during the implosion and removal of concrete debris. This mobilization of sediment is not expected to remain in suspension for an extended period of time in the water column. The duration, shape, and size of turbidity plumes largely depend upon the current velocity at the site during the implosion, and the concentration and grain size of the particles discharged from the concrete caisson. During the implosion, the outer walls of the caisson above and below the mudline will remain intact. Because of this, the caisson will act essentially as a cofferdam and keep the vast majority of debris and sediment trapped, limiting the amount of re-suspended sediment from mixing with the surrounding Bay water. In addition, the air flux generated by the BAS is expected to help contain any turbidity surrounding Pier E3 during the implosion, which would also help to minimize the area affected by resuspended sediments. However, there will be some mixing and some sediment resuspension resulting from the implosion itself, and concrete and other debris falling outside the caisson and potentially settling on the surrounding Bay substrate.

In order to estimate the amount of sediment and turbidity generated during the implosion, Caltrans considered the initial concentration of sediment present during the implosion, the amount of energy generated during the blast (shock or pressure waves), the size and shape of Pier E3, and the BAS surrounding the pier. The model assumed the BAS would be located a maximum distance of 37.73 feet (11.5 meters) away from the pier. Taking into consideration the BAS is designed to attenuate at least 80% of the implosion generated shockwaves, Caltrans determined shockwaves outside of the BAS would be negligible in their ability to resuspend sediment. Therefore, most of the resuspended sediment is expected to be contained within the BAS surrounding the pier. An approximate 0.59 inch-thick layer of sediment, consistent with the average thickness of the low density, oxygen containing surface layer commonly encountered in Bay, would resuspend in the water column, but be contained within the BAS. It should be noted that fine concrete particles (large particles will be released) are not expected to be generated by the blast. The type of charge, weight and sequence of implosion will break the concrete into larger particles. Thus no fines are expected from the break-down of concrete.

In order to evaluate the suspended sediment in a turbidity plume, Caltrans calculated the volume of sediment along with the volume of the surrounding water column (Estimation of Sediment Concentration 2014) and then converted to NTUs. This resulted in an initial suspended sediment concentration of 218 mg/L which equals approximately 160 NTU. This would be a temporary exceedance of current water quality objectives for the Bay and project area; however, the majority of this plume is expected to be contained within the BAS, and to quickly dissipate back to background levels due to the currents and tidal state during the implosion as well as the air flux generated by the BAS. In addition, the implosion will be done during the turn of a peak high tide and ebb current, which will provide a period of time when the tide shifts for any suspended sediment to fall-out, and then a strong current to quickly dissipate the plume. Because the turbidity plume and associated temporary increases in pH will largely be contained within the bubble flux of the BAS surrounding Pier E3, NMFS expects levels of suspended sediments within turbidity plumes to not exceed 50 NTU or result in an incremental increase greater than 10% of the background NTU at a distance greater than 30 meters (100 feet) outside of the BAS from the activity. In addition, a potential pH spike of greater than 0.5 units above ambient may occur within 100 feet of Pier E3. However, as with the turbidity plume, this pH spike would be dispersed within 90 to 120 minutes of the implosion. Caltrans will also conduct water quality monitoring during all activities that may affect water quality parameters.

A debris catchment system will also be used to contain any concrete debris from discharging into the Bay. Therefore a very minimal amount of concrete is expected to be deposited outside the caisson onto the Bay floor. Any debris that is not contained within the catchment system will be removed with a clamshell bucket on a barge-mounted derrick crane, and then placed into the caisson for burial. As concrete or other debris are removed from the Bay floor surrounding Pier E3, fine-grain sediments such as the clay and silt material found in the Bay will be disturbed and generate increased levels of turbidity in the adjacent water column. However, similarly to the turbidity issues described above, NMFS expects that the elevated levels of turbidity related to these activities will be minor and localized due to the relatively small amount of Bay substrate disturbed and the tidal/current circulation present.

There is little direct information available to assess the effects of turbidity associated with construction activities, included debris removal, in San Francisco Bay estuary on listed green sturgeon. High levels of turbidity may affect fish by disrupting normal feeding behavior, reducing growth rates, increasing stress levels, and reducing respiratory functions (Benfield and Minello 1996). However, threatened green sturgeon in the estuary commonly encounter areas of increased turbidity due to storm flow runoff events, wind and wave action, and benthic foraging activities of other aquatic organisms. As benthic foragers, green sturgeon likely generate small amounts of turbidity as they feed. Fish generally react by avoiding areas of high turbidity and return when concentrations of suspended solids are lower. The minor and localized areas of turbidity associated with debris removal activities is not expected to result in harm or injury, or behavioral responses that impair migration, foraging, or make listed green sturgeon more susceptible to predation. If sturgeon temporarily relocate from areas of increased turbidity, areas of similar value are available in San Francisco Bay adjacent to the work sites which offer habitat of equal or better value for displaced individuals. Adjacent habitat areas also provide adequate carrying capacity to support individual sturgeon that are temporarily displaced during demolition and foundation debris removal activities.

During the implosion of the E3 caisson, and concrete debris removal activities, sediments will be suspended and sediment-associated contaminants may be released to the water column. As described above in the discussion related to the effects of turbidity on water quality, higher concentrations of suspended sediments (*i.e.,* turbidity) resuspended during the implosion and debris removal activities will be short-term and localized. NMFS anticipates for turbidity originating during the implosion to be short in duration, and the water quality parameters to quickly return to background conditions. Since contaminants are bound to sediment particles, the amount of contaminants released during these activities is expected to be minor. Any minor and localized elevations in contaminants which might result from those suspended plumes should be quickly diluted by tidal circulation to levels that are unlikely to adversely affect listed green sturgeon.

Green sturgeon, because of their foraging behavior which exposes them to sediments and turbidity, may not react to higher levels of turbidity resulting from the implosion and debris removal. 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 the proposed implosion.

2.4.6. Impacts on Critical Habitat due to High Underwater Sound Pressure Levels and Reduction in Water Quality.

Designated critical habitat for CCC steelhead, Sacramento winter-run Chinook and southern DPS North American green sturgeon occurs in the action area. Pile driving, underwater detonations for pier removal, otter trawling and debris removal (clamshell bucket dredging) activities carried out under the proposed action may impact designated critical habitat for these species. These activities may temporarily alter water quality, foraging habitat, and sediment quality PCEs within salmonid and green sturgeon designated critical habitat.

Underwater Sound Pressure. Temporary impacts to designated critical habitat for salmonids and designated critical habitat of southern DPS green sturgeon are expected during construction of the falsework and trestles required for demolition of the old bridge. Pile driving will adversely affect the water column and benthic substrate of San Francisco Bay within the action area. Impacts to the water column from high sound pressure levels produced during pile driving were discussed previously. There will also be temporary impacts associated with shading and foraging habitat loss within the action areas while temporary structures are in place. However, temporary structures will not be directly located where eelgrass beds have been documented and are not expected to pose impacts to eelgrass from shading. Removal of the old structure will ultimately reduce shading in the project area.

Impacts from pile driving and temporary shading are unlikely to reduce the value of critical habitat for these species in the action area once removal of the existing bridge is complete. Most critical habitat in the action area is either 1) expected to quickly return to pre-project conditions (*e.g.*, sound pressure levels will no longer be present). During construction activities, impacts to the value of critical habitat for these species in the action area is expected to be minimal because of limited extent of most effects and or the short duration of effects (*e.g.*, pile proofing). Habitat outside of the affected areas or times will not be affected.

Furthermore, during the Demonstration Project's implosion activities, a BAS will be installed around Pier E3, which will reduce the area of critical habitat affected by noise that exceeds the established regulatory thresholds that lead to onset of injury or mortality and can alter fish behavior. Under the assumption of an 80% effective BAS, 56,011 acres (a 220,726 meters [(68,000 feet]) linear distance around Pier E3 subject to 150 dB RMS) is within designated critical habitat for CCC steelhead, Sacramento winter-run Chinook and the North American green sturgeon southern DPS. However, a much smaller area of critical habitat corresponding to the 187 dB cSEL metric where take may occur is within 470 acres of critical habitat (a radial distance of 777 meters from the pier) for these species. Additional BMPs will be implemented to minimize the potential for hazardous materials or debris to enter critical habitat during preimplosion construction activities. Because the duration of the implosion is only four to six seconds, and any turbidity generated from the implosion is anticipated to dissipate within 90-120 minutes post-implosion, the critical habitat PCEs for this species will be minimally affected and not permanently altered.

Water Quality. As described above, the effects of the proposed project may result in increased levels of turbidity and the resuspension of sediment-associated contaminants. NMFS does not expect the impacts on water quality will adversely affect PCEs of salmonid or green sturgeon habitat because increases in turbidity levels will be temporary and water quality is expected to improve within a short period following pile driving and removal, otter trawling and within 90-120 minutes following the implosion, and quickly after any clam-shell or crane removal of fallen debris.

Foraging Habitat. Pile driving and removal, otter trawling across the Bay substrate and removal of concrete or other caisson debris from around Pier E3 after the implosion could disturb and remove a very small amount of the top layer substrate habitat surrounding the pier and within the action area and potentially remove invertebrate prey species in that layer. Thus, there will be some short-term impact to invertebrate colonies as a result of these activities. 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 to its pre-disturbed state (McConnaughey *et al*. 2000).

Disturbance to benthic habitat from pile driving and removal, benthic trawling and dredging for debris removal may result in the direct removal of prey resources or the displacement of preferred forage species via the introduction of invasive species to disturbed areas. For salmonids, NMFS believes disturbance to benthic prey resources will be insignificant and discountable since salmonids are not benthic feeders and are likely transiting quickly through the area, not utilizing it for foraging habitat. 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).

While effects on benthic habitats and prey resources for green sturgeon are unclear, due to several factors NMFS does not expect the proposed action will prevent green sturgeon from finding suitable forage at the quantities and quality necessary for normal behavior (*e.g.,* maintenance, growth, reproduction). Green sturgeon are generalist feeders and the reduction of certain prey species by dredging or turbidity around Pier E3 is unlikely to affect availability of prey resources for green sturgeon throughout the Bay. While green sturgeon are known to feed in estuaries, their feeding in sandy bottom substrates has not been confirmed. Research suggests that sturgeon in estuaries primarily forage in shallow, mud-dominated substrates. Because very little is known about the habitat preferences of green sturgeon in the Bay, NMFS has relied upon the best available information described above which suggests green sturgeon do not use deep sandy areas as primary foraging sites. Based on this information, NMFS concludes that proposed implosion of Pier E3 and associated debris removal activities conducted under the proposed action is not likely to reduce the quality of the PCEs for green sturgeon critical habitat within the action area.

Sediment Quality. As described above, sediment quality PCEs for salmonids and 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. For green sturgeon, their association 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 temporary alterations to benthic habitats in deeper areas found around Pier E3 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.

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 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 salmonids and green sturgeon in the action area as well as of their predators and competitors.

2.6 Integration and Synthesis

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

The remaining pile driving activities associated with the SFOBB East Span Seismic Project are expected to result in adverse effects to Federally-listed anadromous salmonids and green sturgeon during construction. For the three listed Central Valley ESUs (Central Valley steelhead DPS, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon), the remaining activities of the SFOBB East Span Seismic Project are expected to result in adverse effects to a very small number of fish from these ESUs, because few individuals are likely to be present within the area of direct construction and demolition impacts. Harmful sound levels from pile driving are predicted to extend several thousand meters from the pile. However, given the geography and bathymetry of San Francisco Bay, and the location of the active pile driving areas along the east side of YBI, combined with the known behavior patterns of salmonids and adult spawning green sturgeon, it is probable that the vast majority of Central Valley anadromous salmonids are likely to be on the north side of San Francisco Bay en route between the Golden Gate and their natal Central Valley streams. Similarly, adult spawning green sturgeon will likely to be located on the north side of San Francisco Bay during migration, en route between the Golden Gate Bridge and the Sacramento River during construction activities. Since this portion of San Francisco Bay is several kilometers from the area that will be subject to the highest sound pressure levels, only very small numbers of three Central Valley ESU salmonids and adult spawning green sturgeon are anticipated to be in the action area and exposed to harmful sound pressure levels. Thus impacts to Central Valley salmonid numbers are very small and likely exert no discernible effect on future adult returns.

CCC steelhead must pass through the action area on route to natal streams within the south Bay, and during juvenile emigration from south Bay tributaries to the Pacific Ocean. CCC steelhead was listed as threatened under the ESA because their numbers are dramatically reduced from historical estimates. This DPS does retain resiliency in the face of natural environmental fluctuations, but is at risk because its small numbers and other factors reduce its ability to persist in the face of natural disturbances. For CCC steelhead, NMFS expected up to .0003% annually of the outmigrating juvenile and post-spawned adult population originating from south San Francisco Bay tributary streams would be adversely affected by pile driving during the 2012-2017 construction periods analyzed in the 2012 BO. For the remainder of bridge east span removal activities in 2015-2017, NMFS expects this number to be even smaller since less pile driving will be required for the remaining bridge dismantling activities of the old bridge. This impact occurs to populations that have likely suffered recent losses from pile driving that occurred during the installation of temporary piles since the project began construction (now part of the Environmental Baseline). Numerically, south San Francisco Bay steelhead represent a very small portion of the entire CCC steelhead, but these south Bay tributaries represent a significant and unique portion of the geographic distribution of this DPS. While the magnitude of loss is very small, these combined losses of adult and juvenile (smolt) salmonids associated with the bridge demolition of the SFOBB East Span Seismic Project may manifest as a reduction in the number of adults returning for the next generation of the south Bay CCC steelhead populations because, for example, these losses are in addition to the most recent, previous pile driving impacts between 2009 and 2015 (see Environmental Baseline). However, the likely impacts of this project are not expected to appreciably reduce the resiliency of these south Bay populations, (*i.e.*, their likelihood of survival and recovery) because salmonids have evolved and are adapted to variable systems (Bisson *et al*. 1997); and favorable water years and ocean conditions are likely to allow for subsequent years with greater population abundance that will replace the small number of steelhead killed by this project. Improvements to baseline conditions as a result of the restoration efforts funded by Caltrans and others to restore, enhance, or create salmonid habitat may improve reproductive success and survival of CCC steelhead. In consideration of the above, the demolition activities associated with the SFOBB East Span Seismic Project are not anticipated to reduce the likelihood of the survival and recovery of the local CCC steelhead populations or the Central California Coast DPS.

The 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 Central, South and North San Francisco 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 green sturgeon depend on have been reduced, and periodic releases of contaminants occur from ships, piers, adjacent land areas, and storm water runoff.

Similar to CCC steelhead, the potential impacts from pile driving that have occurred from the installation of piles since the project began construction may have caused injury or mortality or adverse behavioral changes to green sturgeon, potentially reducing levels of juvenile production and adult returns. As described above, a small number of green sturgeon may be injured or killed by the remaining pile driving activities. The number of green sturgeon affected is likely to be fewer than estimated in the 2012 Biological Opinion, because pile driving work is now likely to be less than previously anticipated. Green sturgeon are also likely to be injured or killed by the detonation of controlled charges that are part of the Demonstration project and injured or killed if captured in otter trawls.

Since the Demonstration Project's proposed method for pier removal utilizing underwater explosives will only occur in November during the seasonal avoidance period for listed salmonid species, only southern DPS green sturgeon may be present within the action area during the detonation of controlled charges. The underwater blast and associated turbidity has the potential to affect listed fish through exposure to high underwater sound pressure levels and degradation of water quality. During the blast, water quality in the action area may be degraded through temporary increases in underwater sound pressure levels, and increases in turbidity from breaking concrete and sediment disturbance. However, sediment-associated contaminants resuspended within the water column are not expected to occur at levels known to cause reductions in fitness to listed fish. Increases in turbidity produced during otter trawling and after the implosion and debris removal will be temporary and similar to the natural conditions typically encountered by listed fish. Turbidity effects associated with plumes will likely result in minor and temporary changes to fish behavior, and are not expected to adversely affect green sturgeon. Furthermore, the removal of Pier E3 would result in the permanent creation of approximately 4,144 cubic meters of open water (pelagic) habitat.

Any green sturgeon that are captured during otter trawls may be stressed, injured or killed from the sampling methods alone. This would also compound any injury or stress that results from exposure to the underwater blast post-implosion. As described previously, some green sturgeon that are temporarily disoriented or sustain survivable injury could be captured during the otter trawling and subjected to additional stress or injury which could affect their chances of survival. However, due to the timing of the implosion during the month of November, very few green sturgeon, are expected to be located within the action area and are unlikely to be captured during the otter trawl surveys post-implosion. As with pile driving and underwater blast sound exposure, possible injury or mortality resulting from capture in the nets during otter trawling may affect a small number (3 or fewer) of juvenile or subadult green sturgeon

Although the population of green sturgeon is low, and a small number of green sturgeon may have been harmed or killed by previous pile driving activities at this site, the possible injury or mortality resulting from exposure to high SPLs during the remaining pile driving and pier implosion activities, as well as the potential capture and loss in otter trawls, of a small number of juvenile or subadult green sturgeon is not expected to appreciably decrease the number of returning adults, because of the number of juveniles produced by these populations. Since no spawning or freshwater rearing habitat will be affected by the proposed activities or operations, impacts on spawning survival and survival from egg to juvenile are not expected. In addition, because green sturgeon are long-lived species, it is presumed that adults not harmed or killed by this project will continue to spawn in future years and produce juveniles to replace any lost during construction of the project. Therefore, the abundance, distribution, and reproduction of the southern DPS green sturgeon is not likely to be appreciably reduced by the associated effects of the project's actions during the remaining SFOBB bridge demolition work and the Demonstration Project.

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% 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. However, the adverse effects of this project on listed salmonids, green sturgeon, and their critical habitats will have ceased prior to the climate change impacts described above being realized.

2.7 Conclusion

After reviewing the best available commercial and scientific information regarding the current status of listed anadromous salmonids and 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 proposed bridge demolition and dredging activities for the SFOBB East Span Seismic and Demonstration Projects are not likely to jeopardize the continued existence of CCC steelhead, Central Valley steelhead, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon or southern DPS green sturgeon.

After reviewing the best available commercial and scientific information regarding the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed remaining activities for the SFOBB East Span Seismic and Demonstration Project and are not likely to adversely modify or destroy the critical habitat of CCC steelhead, Central Valley steelhead, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, or 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.

2.8.1.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur to Sacramento winter-run Chinook Salmon ESU, Central Valley spring-run salmon ESU, Central Valley steelhead DPS, Central California Coast steelhead, and the North American green sturgeon southern DPS as follows:

Pile driving with an impact hammer is expected to result in incidental take in the form of injury, mortality to salmonids and green sturgeon through exposure to temporary high SPLs (> 206 dB peak SPL or 187 dB SEL) within the water column during the installation of the temporary trestles and falsework require for bridge dismantling. The number of salmonids and green sturgeon that may be incidentally taken during activities is expected to be very small. Because finding dead or injured fish will be difficult due to their small size in relation to the size of the action area, the difficulty in observing dead or injured fish in the waters of the bay due to depth and the presence of predators and scavengers such as birds, NMFS will use the area of sound pressure wave impacts extending into the water column from each pile, and the time period for pile driving as a surrogate for number of fish. For salmonids and southern DPS green sturgeon, those fish located within the 38 m diameter from the pile during attenuated pile driving of the 36-inch diameter steel piles, within the 14 m diameter for unattenuated pile proofing of the 36-inch piles, and within the 65 m distance from the Yerba Buena Island shoreline during the installation of the H-piles may be injured or killed. Beyond these distances, extending out to the 796 m, 3981 m and 1311 m diameters corresponding with SPLs > 150 dB RMS, of the above events fish may exhibit behavioral responses such as agitation or rapid bursts in swimming speeds. If Caltrans' monitoring indicates that sound pressure levels greater than 206 dB peak (re: 1 μPa), or 187 dB

SEL (re: 1 μPa2sec), or 150 dB RMS (re: 1 μPa) extend beyond these distances the amount of incidental take may be exceeded.

During the Demonstration Project, NMFS anticipates that take of threatened southern DPS North American green sturgeon will be in the form of mortality and/or injury through exposure to underwater sound pressure levels produced during the test blast and controlled implosion of Pier E3. The number of listed green sturgeon that may be incidentally taken during the Demonstration Project is expected to be very low due to duration of the blast (no more than 6 seconds) and the time of year (November) when the blast will take place. However, any fish located within a distance of 777 meters (2,550 feet) of the pier, corresponding to the area where sound pressure levels could be equal to or greater than 187 dB cSEL could be injured or killed. No ESA-listed fish species less than two grams are expected to be present therefore only the distance to reach the 187 dB cSEL threshold represents the entire area where fish may be injured or killed. Beyond this distance, extending out to the 220,726 meters (68,000 feet) distance corresponding with SPLs > 150 dB RMS, of the above events fish may exhibit behavioral responses such as agitation or rapid bursts in swimming speeds. The number of ESA-listed green sturgeon that may be affected during debris removal activities is expected to be very low due to the area being used primarily as a migration corridor and fish are expected to quickly transit through the area where they may encounter high levels of turbidity. As with pile driving, finding injured or dead green sturgeon will be difficult due to their small size in relation to the size of the action area, the difficulty in observing dead or injured fish in the waters of the bay due to depth and the presence of predators and scavengers such as birds. Therefore NMFS will use sound pressure levels and the distance to reach thresholds in the water column as a surrogate for the number injured or killed. If Caltrans' monitoring indicates that sound pressure levels greater than 206 dB peak (re: 1 μPa), or 187 dB SEL (re: 1 μPa2sec), or 150 dB RMS (re: 1 μPa) extend beyond these distances the amount of incidental take may be exceeded during the implosion.

During otter trawling after the explosion, NMFS anticipates take of threatened southern DPS North American green sturgeon in the form of injury or mortality through being dragged through the water column and handling stress as a result of capture in the nets. The number of listed green sturgeon that may be incidentally taken during the otter trawling is expected to be low due to time of year (November) when the sampling will take place. As described in the preceding biological opinion, NMFS used the Bay Study to estimate the number of green sturgeon that may be captured and injured or killed by otter trawling NMFS conservatively estimates no more than three green sturgeon would be captured in the otter trawl nets. This number is likely an overestimate and can be verified since actual fish counts will be conducted of fish captured in the nets. If more than 3 green sturgeon are captured, injured or killed during otter trawling after the explosion, incidental take will have been exceeded.

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 southern DPS of North American green sturgeon:

1. Utilize measures to minimize and avoid the take of salmonids and green sturgeon from pile driving activities during dismantling the existing bridge.

2. Utilize measures to minimize and avoid the take of green sturgeon from dismantling pier E3. Ensure blast methods and minimization measures are properly implemented and assist in the evaluation of project effects on listed green sturgeon.

3. Utilize measures to minimize and avoid take of green sturgeon during otter trawl sampling.

4. Ensure the fisheries and hydroacoustic monitoring plans for the SFOBB Seismic Safety Projects and Demonstration Projects are properly implemented.

2.8.4 Terms and Conditions

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

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

a. Ensure all avoidance and minimization measures as described in the Fisheries and Hydroacoustic Monitoring Plan during pile driving are properly implemented.

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

a. Ensure blast methods and all avoidance and minimization measures as described in the Project Description are properly implemented.

The following terms and conditions implements reasonable and prudent measure 3:

a. Ensure that the otter trawl protocols are properly implemented.

b. Ensure that capture and handling methods are incorporated in order to reduce the duration of processing time and minimize associated capture and handling stress to green sturgeon.

The following terms and conditions implements reasonable and prudent measure 4:

a. Real-time monitoring shall be conducted to ensure that underwater sound levels analyzed in this biological opinion do not exceed the following distances:

    - Attenuated piles, 206 dB peak SPL at 1m (2 m diameter), 187 dB accumulated SEL at 34 m (68 m diameter), and 150 dB RMS at 398 m (796 m diameter);

    - Proofing of piles, 206 dB peak SPL at 7 m (14 m diameter), 187 dB accumulated SEL at 19 m (38 m diameter), and 150 dB RMS at 3981 m (7962 m diameter);

    - Steel H-piles, 206 dB peak SPL at 10 m, 187 dB accumulated SEL at 65 m (radial distance), and 150 dB RMS at 1311 m.

    - For the BAS attenuated implosion described in this opinion: 206 dB peak at 245 meters (820 feet), and 187 dB cSEL at 777 meters (2,550 feet), and 150 dB RMS at 220,726 meters (68,000 feet). For the test charge, the distance for 206 dB peak is 27 meters (88 feet), and for 150 dB RMS, 1,219 meters (4,000 feet).

b. Caltrans shall submit to NMFS a draft monitoring and reporting program for review and approval 60 days prior to the start of the implosion component of marine foundation removal. Caltrans shall monitor underwater sound during the controlled charge implosion activities as described in the final monitoring and reporting plan. This plan shall include provisions to provide summaries of the hydroacoustic monitoring results, specifically, the report shall include:

    - A description of the locations of hydroacoustic monitoring stations that were used to document the extent of the underwater sound footprint during pile driving and the implosion and test blast, including the number, location, distances, and depths of the hydrophones and associated monitoring equipment;

    - The reports will also include observations of bird predation and behavior; and evaluation of fish mortality and injury rates through the use of visual observations and collections after the implosion.

c. Any observed dead fish will be collected and preserved.

d. All ESA and EFH-species of fish killed and collected by this project must be immediately frozen or otherwise preserved to be used for potential analyses of the blast effects on fish. NMFS shall be conferred with regarding where to send fish for necropsies.

e. All reports and other materials to be submitted to NMFS described in the above terms and conditions shall be submitted to:

Jacqueline Meyer c/o the
North Central Coast Office Supervisor
National Marine Fisheries Service
777 Sonoma Ave., Room 325
Santa Rosa, California 95404
Phone (707) 575-6057
Fax (707) 578-3435

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. To avoid adverse impacts to anadromous fish species, use of impulsive sound source devices (*i.e.*, underwater explosives and pile driving) during peak migration periods should be avoided.
2. To avoid attracting fish with lights during nighttime, all construction and demolition activities should be limited to daylight hours.
3. To minimize the effects of sound pressure waves to anadromous fish species, new and more effective sound attenuation methods should be researched, developed and incorporated.

2.10 Reinitiation Notice

This concludes formal consultation for the San Francisco-Oakland Bay Bridge Demonstration Project in San Francisco Bay, San Francisco County, 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 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

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

This analysis is based, in part, on the EFH assessment provided by Caltrans and descriptions of EFH for Pacific Coast Groundfish (PFMC 2005), Coastal Pelagic species (PFMC 1998), and Pacific Coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

Effects of the proposed project will impact EFH for various federally managed fish species within the Pacific Coast Groundfish (PFMC 2005), Pacific Coast Salmon (PFMC 1999), and Coastal Pelagic Species (PFMC 1998) FMPs. Furthermore, the project area is located in an estuary Habitat Areas of Particular Concern for various federally managed fish species within the Pacific Coast Groundfish FMP.

3.2 Adverse Effects on Essential Fish Habitat

Adverse effects to Essential Fish Habitat within San Francisco Bay will occur through (1) increased underwater sound pressure levels in the water column, (2) increased turbidity in the water column, (3) otter trawling, and (4) disturbance of benthic biological community, including removal of prey, and physical habitat.

3.2.1 Effects of Underwater Sound Pressure on EFH

Pile driving for this project will create elevated underwater sound pressure waves in EFH with potential impacts to fish species managed under the MSA. Fish can be injured or killed when exposed to elevated underwater sound pressure waves generated from pile driving. Elevated sound levels will temporarily adversely affect EFH. In most cases fish will likely leave the area in response to sound transmitted through water and sediment. In some situations they may be injured or killed.

The use of controlled charges to implode Pier E3 will create high underwater sound pressure waves in EFH with potential impacts to fish species managed under the MSA. Fish can be injured or killed when exposed to high underwater sound pressure waves generated from underwater explosives. These high sound levels will temporarily adversely affect EFH. The duration of the implosion will last no longer than six seconds, thus fish that are not located within injury zones will most likely leave the area in response to sound transmitted through water and sediment. In some situations they may be injured or killed. Noise impacts to fish are described in detail in the preceding biological opinion's Effects of the Action, section 2.4.

3.2.2 Turbidity

Installation and pulling of temporary piles, and towing an otter trawl across the Bay substrate will result in short-term localized increases in turbidity. Resuspension of bottom sediments is expected to occur with piling removals and otter trawling. However, the extent and duration of this is expected to be minor and temporary. If sediment loads remain high for an extended period of time however, the primary productivity of an aquatic area may be reduced (Cloern 1987). Turbidity would generally be expected to dissipate quickly due to strong currents in the project area. Fish may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and C.A. Simenstad 2001) if exposed to excessive high levels of turbidity. However, turbidity impacts to fish are expected to be temporary and minor as fish tend to move out of areas with persistently high levels of suspended sediment.

As a result of the underwater implosion, concrete debris and disturbed substrates will create elevated levels in turbidity and suspended sediments. While fish in San Francisco Bay are exposed to naturally elevated concentrations of suspended sediments resulting from storm flow runoff events, wind and wave action, and benthic foraging activities of other aquatic organisms (Schoelhammer 1996), concentrations of suspended sediments may be significantly elevated to have direct effects on fish behavior. If suspended sediment loads remain high for an extended period of time, fish may suffer increased larval mortality (Wilber and Clarke 2001), reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and Simenstad 2001).

The frequency and duration of the turbidity plume resulting from pile driving and removal, the implosion, trawling, and debris removal, as well as the sediment and/or other pollutant concentration within the plume, generally depend upon the size and quality of the bottom sediments and the frequency and duration of the clamshell dredging events. As discussed in the biological opinion (section 2.4.5 an initial turbidity spike may occur as a result of the implosion, Caltrans estimates this to be 218 mg/L which equals 157 NTU. Although this is an exceedance of the current water quality objectives for the Bay, this plume is expected to quickly dissipate back to background levels due to the currents and tidal state, and be contained close to the caisson within the BAS. Outside the BAS, NMFS expects levels of suspended sediments within turbidity plumes to not exceed 50 NTU or result in an incremental increase greater than 10% of the background NTU at a distance greater than 30 meters (100 feet) from the activity, especially when the activity occurs within 1,000 meters (3,200 feet) of an eelgrass bed or sand flat. In addition, a potential pH spike of greater than 0.5 units above ambient may occur within 100 feet of Pier E3. However, as with the turbidity plume, this pH spike would be dispersed within 90 to 120 minutes of the implosion. During the controlled implosion event, additional water quality monitoring will be conducted to detect and measure conductivity and temperature (including data for depth at sample taken), pH, dissolved oxygen, metals, and other contaminants. It is expected that fish species encountering the turbidity plumes will react behaviorally to the effects of the plume and either move away from or avoid the plume. These effects are expected to be temporary and there is ample area in the surrounding water that is free from turbidity.

3.2.3 Eelgrass Beds and Benthic disturbance

No eelgrass beds are located within the areas likely affected by turbidity from benthic otter trawling, the implosion or debris removal activities. Historical occurrences of eelgrass (a HAPC) immediately off the southeastern shore of YBI were located approximately 0.64 kilometers (0.40 mile) west of Pier E3, away from the proposed implosion. Presence of eelgrass in the area was noted in 1999, 2003, 2004, and in 2005 (Merkel & Associates 2008). No eelgrass surveys occurred in 2006, and surveys completed in 2007 and 2009 did not find eelgrass beds in this location (Merkel & Associates 2008, 2010). However, all eelgrass beds in the vicinity of the entire SFOBB Project have been designated as environmentally sensitive areas (ESAs). To protect and demarcate these ESAs, Caltrans will install and maintain buoys along their outer boundary. To protect eelgrass beds during the Demonstration Project, all project-related equipment (barges, cranes, piles, BAS, etc.) will be placed and/or staged outside the eelgrass ESA buoys. However, Caltrans will complete an eelgrass survey of the area southeast of YBI prior to the implosion of Pier E3. If eelgrass is found in this location, avoidance and minimization measures will be evaluated and implemented, where practical. Eelgrass within Clipper Cove is protected from implosion-related impacts (*e.g.*, sediment and turbidity) by the northeastern side of YBI and should not be affected. Since light availability is a major factor controlling the distribution of eelgrass in the Bay (Zimmerman *et al.* 1990; Zimmerman *et al.* 1994), and eelgrass was observed off YBI prior to the Pier E3 implosion, Caltrans will implement light and turbidity monitoring, consistent with the Bay Light Monitoring Protocol (NMFS 2010).

Benthic otter trawling and removal of debris following the implosion with the use of a clamshell bucket dredge will disturb small areas of benthic habitat surrounding Pier E3 and within the action area by disturbance and removal of sediment. As discussed previously in this biological opinion (see section 2.4.6, benthic communities within areas that are repeatedly disturbed on an annual and interannual basis may have difficulty recovering. Empirical research suggests that disturbance to the biological community, combined with the physical alteration of habitat, results in a loss of ecological function over varying timescales (Reish 1961, Oliver *et al*. 1977, Thrush *et al.* 1995, Watling *et al.* 2001). Ecological function may never be equivalent to that of the pre-disturbed habitat. However, since this area is located within the deep shipping channel of the Bay, it has been subjected to repeated disturbance from dredging and years of construction related to the SFOBB construction. Debris removal activities for this project are expected to only remove pieces of debris from the substrate, not extensively dredge sediment. Thus the effects of debris removal are expected to minimally affect the benthic habitat surrounding Pier E3.

Depending on how many more trestles are needed to be constructed between 2015 and 2017, a maximum of 2.4 acres of temporary overwater shading could occur (however, we expect less trestle work to be required than considered in 2012 as a result of recent project modifications described previously). Shading is known to decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, and reduce the density of benthic invertebrates (Helfman 1981; Glasby 1999; Struck, Craft *et al.* 2004; Stutes, Cebrian *et al.* 2006); all of which lead to an overall reduction in the quality of EFH. Effects of shading from trestles will be temporary and will, for the most part, occur in areas where overwater structures already exist. Falsework will be installed beneath the existing structure and will not result in increased shading. Temporary structures, including trestles, will not be directly located where eelgrass beds have been documented and are not expected to pose impacts to eelgrass from shading. Removal of the old structure will ultimately reduce shading in the project area.

3.3 Essential Fish Habitat Conservation Recommendations

As described in the above effects analysis, NMFS has determined that the proposed SFOBB Demonstration Project would adversely affect EFH for various federally managed fish species within the Pacific Coast Groundfish, Pacific Coast Salmonid, and Coastal Pelagic FMPs. However, there are no practical EFH Conservation Recommendations to provide because impacts to EFH are expected to minor, temporary and localized (see reasons listed below). Any recommendations to avoid or minimize impacts would not result in impact reductions. For example, use of a silt curtain to minimize elevated levels of turbidity is not necessary because the elevated levels of turbidity expected with this project are so minor, and the BAS bubble flux surrounding Pier E3 during the implosion will help to contain and dissipate any turbidity generated during the blast. Any sediment disturbance and associated turbidity plumes that occur during debris removal activities are also expected to be minor and temporary.

1. Impacts from elevated underwater sound are expected to short in duration (four to six seconds total during the implosion and short periods during pile driving) and will not appreciably diminish the value of EFH once the project is completed.

2. Otter trawling will only occur in a small portion of the action area for a very limited duration (less than one day) and will not appreciably diminish the value of EFH once the sampling is completed.

3. Elevated levels of turbidity associated with this project are expected to be minor, temporary and localized.

4. Suspension of sediment-associated contaminants is anticipated to occur at a small scale that will not lead to assimilation into the food web.

5. Disturbance of benthic habitat will occur at a small scale and habitat is expected to recover within a few months to a few years.

6. Temporary shading from trestle/falsework construction will be temporary, and will not pose any impacts to existing eelgrass beds.

3.5 Supplemental Consultation

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

4.0 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.

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 California Department of Transportation. Other interested users could include the Corps of Engineers, BCDC, USFWS, CDFW, or the State Water Resources Control Board. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts[8]). The format and naming adheres to conventional standards for style.

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.

Objectivity

Information Product Category: Natural Resource Plan

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

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

[8] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR-2015-2708

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

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

5.0 REFERENCES

Abdul-Aziz, O. I, N. J. Mantua, K. W. Myers. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus spp.)* in the North Pacific Ocean and adjacent seas. Canadian Journal of Fisheries and Aquatic Sciences 68(9):1660-1680.

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2002. Status Review for North American Green Sturgeon, *Acipenser medirostris*. NMFS, SWFSC, USGS, North Carolina State University, NWFSC, Santa Cruz, Raleigh, Seattle.

Adams, P. B., and coauthors. 2007. Population status of North American green sturgeon *Acipenser medirostris*. Environmental Biology of Fishes 79:339-356.

Allen, M. A., and T. J. Hassler. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest): Chinook salmon. U.S. Fish and Wildlife Service.

Allen, P. J., and J. J. Cech. 2007. Age/size effects on juvenile green sturgeon, *Acipenser medirostris*, oxygen consumption, growth, and osmoregulation in saline environments. Environmental Biology of Fishes 79:211-229.

Alpine, A. E., and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in in an estuary. Limnology and Oceanography 37(5):946-955.

AMEC Foster Wheeler. (2015). Technical Memorandum – Pier E3 Caisson Water Quality.

Atcheson, M. E., K. W. Myers, D. A. Beauchamp, and N. J. Mantua. 2013. Bioenergetic Response by Steelhead to Variation in Diet, Thermal Habitat, and Climate in the North Pacific Ocean. Transactions of the American Fisheries Society 141(4):1081-1096.

Atcheson, M. E., K. W. Myers, N. D. Davis, and N. J. Mantua. 2012. Potential trophodynamic and environmental drivers of steelhead (*Oncorhynchus mykiss*) productivity in the North Pacific Ocean. Fisheries Oceanography 21(5):321–335.

Bakke, A. M., and coauthors. 2010. Competition between selenomethionine and methionine absorption in the intestinal tract of green sturgeon (*Acipenser medirostris*). Aquatic

Toxicology 96:62-69.

Barnard, P. 2014. Draft Report: Bathymetric Change analysis for West-central Bay and Suisun Bay, 2008-2014. U.S. Geological Survey, Santa Cruz, California.

Barnard, P., and R. Kvitek. 2010. Anthropogenic Influence on Recent Bathymetric Change in West-Central San Francisco Bay. San Francisco Estuary and Watershed Science 8(3):1-13.

Barnard, P. L., D. H. Schoellhamer, B. E. Jaffe, and L. J. McKee. 2013. Sediment transport in the San Francisco Bay Coastal System: An overview. Marine Geology 345:3-17.

Benfield, M. C., and T. J. Minello. 1996. Relative effects of turbidity and light intensity on reactive distance and feeding of an estuarine fish. Environmental Biology of Fish 46(2):211-216.

Bilby, R. E., B. R. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, R. E., B. R. Fransen, P. A. Bisson, and J. K. Walter. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, U. S. A. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Bjorkstedt, E. P., and coauthors. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce, National Marine Fisheries Service, Southwest Fisheries Science Center, NOAA Technical Memorandum, NMFS-SWFSC-382, Santa Cruz, CA.

Bond, M. H. 2006. Importance of estuarine rearing to Central California steelhead (*Oncorhynchus mykiss*) growth and marine survival. Master's Thesis. University of California, Santa Cruz, CA.

Brewer, P. G., and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO2 Problem. Scientific American.

Busby, P. J., and coauthors. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Sceince Center and Southwest Region Protected Resources Division, NOAA Technical Memorandum, NMFS-NWFSC-27.

CALFED Bay-Delta Program. 2000. Ecosystem Restoration Program Plan, Volume II. Technical Appendix to Final PEIS/EIR.

Caltrans 2015a. Biological Assessment and Essential Fish Habitat Assessment for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. Report for National Marine Fisheries Service. February 2015. EFIS#0412000608.

Caltrans 2015b. Water Quality Study San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. March 2015. Report Number 04-SF-80 / 04-ALA-80 KP 12.2 - 14.3 / KP 0.0 - 2.1

Capiella, K., C. Malzone, R. Smith, and B. Jaffe. 1999. Sedimentation and bathymetry changes in Suisun Bay (1867–1990). U.S. Geological Survey Open-File Report 99–563.

Cayan, D., M. Tyree, and S. Iacobellis. 2012. Climate Change Scenarios for the San Francisco Region. Prepared for California Energy Commission. Publication number: CEC-500-2012-042. Scripps Institution of Oceanography, University of California, San Diego

CDFG (California Department of Fish and Game). 1998. Report to the Fish and Game Commission: A Status Review of the Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage, 98-01.

CDFG (California Department of Fish and Game). 2000. Sacramento River winter-run chinook salmon. Wildlife & Inland Fisheries Division, Fisheries Branch Program Ocean Salmon Project, Marine Region.

CDFG (California Department of Fish and Game). 2002a. California Department of Fish and Game comments to NMFS regarding green sturgeon listing, California Department of Fish and Game, Inland Fisheries Division, Sacramento, California.

CDFG (California Department of Fish and Game). 2002b. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing.

CDFG (California Department of Fish and Game). 2008. Chinook Salmon Populations for the Upper Sacramento River Basin In 2008. Prepared by Douglas Killam, Northern Region-Department of Fish and Game Sacramento River Salmon and Steelhead Assessment Project. Revised 1-11-2010. SRSSAP Technical Report No. 09-1-2009.

Chambers, J. S. 1956. Research Relating to Study of Spawning Grounds in Natural Areas. State of Washington, Department of Fisheries.

Chin, J. L., F. L. Wong, and P. R. Carlson. 2004. Shifting Shoals and Shattered Rocks - How Man Has Transformed the Floor of West-Central San Francisco Bay. U. S. G. Survey, editor, Menlo Park, CA.

Cloern, J. E., N. Knowles, L. R. Brown, D. Cayan, M. D. Dettinger, T. L.Morgan, D. H. Schoellhamer, M. T. Stacey, M. van der Wegen, R. W. Wagner, and A. D. Jassby. 2011. Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change. PLoS ONE 6(9):13.

Cloern, J. E., and A. D. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: discoveries from four decades of study in San Francisco Bay. Reviews of Geophysics 50.

Conomos, T. J., R. E. Smith, and J. W. Gartner. 1985. Environmental Setting of San Francisco Bay. Hydrobiologia 129(OCT):1-12.

Cox, P., and D. Stephenson. 2007. A changing climate for prediction. Science 113:207-208.

David, N., and coauthors. 2009. Mercury concentrations and loads in a large river system tributary to San Francisco Bay, California, USA. Environmental Toxicology and Chemistry 28(10):2091–2100.

Demko, D. B., C. Gemperle, A. Phillips, S. P. Cramer, and D. Neeley. 2000. Outmigrant Trapping of Juvenile Salmonids in the Lower Stanislaus River Caswell State Park Site 1999. S.P. Cramer & Associates, Inc., Gresham, OR.

Doney, S. C, M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4:11-37.

Dumbauld, B. R., D. L. Holden, and O. P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest estuaries. Environmental Biology of Fishes 83:283-296.

Dunford, W. E. 1975. Space and food utilization by salmonids in marsh habitats in the Fraser River Estuary. M.S. Thesis. University of British Colombia, Vancouver.

DWR. 2013. San Francisco Bay Hydrologic Region. California Water Plan Update 2013. State of California Natural Resource Agency Department of Water Resources, Sacramento, California.

Feely, R. A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, F.J. Millero. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. Science 305:362-366.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8(3):870-873.

Fregoso, T. A., A. C. Foxgrover, and B. E. Jaffe. 2008. Sediment deposition, erosion, and bathymetric change in central San Francisco Bay: 1855–1979. . U.S. Geological Survey Open-File Report 2008–1312.

Fukushima, L., and E. W. J. Lesh. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Fish and Game 84(3):133-145.

Gaspin, Joel B. 1975. Experimental investigations of the effects of underwater explosions on swimbladder fish, 1: 1973 Chesapeake Bay Tests. Naval Surface Weapons Center Silver Springs Maryland 20910. NSWC/WOL/TR 75-58

Gilbert, G. K. 1917. Hydraulic mining debris in the Sierra Nevada. U.S. Geological Service Professional Paper 105.

Good, T. P., R. S. Waples, and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast Pacific ecosystem: evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. Fisheries 25(1):15-21.

Hallock, R. J., and F. W. Fisher. 1985. Status of winter-run chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. California Department of Fish and Game, Anadromous Fisheries Branch.

Hallock, R. J., W. F. Van Woert, and L. Shapovolov. 1961. An Evaluation of Stocking Hatchery-reared Steelhead Rainbow Trout (*Salmo Gairdnerii Gairdnerii*) in the Sacramento River System. California Department of Fish and Game, Fish Bulletin No. 114.

Hanes, D. M., and P. L. Barnard. 2007. Morphological Evolution in the San Francisco Bight. Journal of Coastal Research.

Hanson, L. C. 1993. The Foraging Ecology of the Harbor Seal, *Phoca vitulina*, and the California Sea Lion, *Zalophus Californianus*, at the Mouth of the Russian River, California. Master's Thesis. Sonoma State University, Cotati, California.

Hayes, S., and coauthors. 2012. Using Archival Tags to Infer Habitat Use of Central California Steelhead and Coho Salmon. Advances in Fish Tagging and Marking Technology 76:471-492.

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

Healey, M. C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in* C. Groot, and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver, BC.

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

Huff, D. D., S. T. Lindley, P. S. Rankin, and E. A. Mora. 2011. Green sturgeon physical habitat use in the coastal Pacific Ocean. PLOS One 6(9):e25156.

IEP (Interagency Ecological Program) Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review Existing Programs, and Assessment Needs. In: Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII.

Israel, J. A., K. Jun Bando, E. C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences 66:1491–1504.

Jaffe, B. E., R. E. Smith, and A. C. Foxgrover. 2007. Anthropogenic influence on sedimentation and intertidal mudflat change in San Pablo Bay, California: 1856–1983. Estuarine Coastal Shelf Science 73:175-187.

Jahn, A. 2004. On the Presence /Absence of Listed Salmonid ESUs in Central San Francisco Bay. Report for the Long Term Maintenance Strategy (LTMS) for the U.S. Army Corps of Engineers dredging program. LTMS Science Group. March 2004

Kadir, T., L. Mazur, C. Milanes, and K. Randles. 2013. Indicators of Climate Change in California. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment Sacramento, CA.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay estuary, California. Environmental Biology of Fishes 79:281-295.

Kimmerer, W., E. Gartside, and J. J. Orsi. 1994. Predation by an introduced clam as the likely cause of substantial declines in zooplankton of San Francisco Bay. Marine Ecology Progress Series 113:81–93.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1981. Influences of Freshwater Inflow on Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin Estuary. U.S. Fish and Wildlife Service, FWS/OBS-81/04, Stockton CA.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1982. Life History of Fall-run Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, in the Sacramento- San Joaquin Estuary, California. Pages 393-411 *in* Estuarine Comparisons. Academic Press, Inc.

Knowles, N., and D. R. Cayan. 2004. Elevational dependence of projected hydrologic changes in the San Francisco estuary and watershed. Climate Change 62:313–336.

Levings, C. D. 1982. Short Term Use of a Low Tide Refuge in a Sandflat by Juvenile Chinook, (*Oncorhynchus tshawytscha*), Fraser River Estuary. Department of Fisheries and Oceans, 1111, West Vancouver, B.C.

Levy, D. A., and T. G. Northcote. 1982. Juvenile Salmon Residency in a Marsh Area of the Fraser River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 39(2):270-276.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science, 5.

Lindley, S. T., and coauthors. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council.

Lindley, S. T., and coauthors. 2011. Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries. Transactions of the American Fisheries Society 140:108–122.

Lindley, S. T., and coauthors. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182–194.

Lindley, S. T., and coauthors. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Linton TL, AM Landry, Jr, JE Buckner, Jr, and RL Berry. 1985. "Effects upon selected marine organisms of explosives used for sound production in geophysical exploration." Texas Journal of Science 37:342–353.

Luers, A. L., D. R. Cayan, G. Franco, M. Hanemann, and B. Croes. 2006. Our changing climate, assessing the risks to California; a summary report from the California Climate Change Center. California Climate Change Center.

MacFarlane, B. R., and E. C. Norton. 2002. Physiological ecology of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin 100:244-257.

McCormick, S. 1994. Ontogeny and evolution of salinity tolerance in anadromous salmonids: Hormones and heterochrony. Estuaries 17(1):26-33.

McDonald, J. 1960. The behavior of Pacific salmon fry during the downstream migration to freshwater and saltwater nursery areas. Journal of the Fisheries Research Board of Canada 17:655-676.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units.

Appendix A4: Population Size. National Marine Fisheries Services, Northwest Fisheries Science Center & Southwest Fisheries Science Center.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, CA.

McEwan, D. R. 2001. Central Valley steelhead. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(1):44.

McKee, L. J., M. Lewicki, D. H. Schoellhamer, and N. K. Ganju. 2013. Comparison of sediment supply to San Francisco Bay from watersheds draining the Bay Area and the Central Valley of California. Marine Geology 345:47-62.

Moser, S., J. Ekstrom, and G. Franco. 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California. A Summary Report on the Third Assessment from the California Climate change Center. July. CEC-500-20102-007S.

Moyle, P. B. 2002. Inland fishes of California. University of California Press, Berekely and Los Angeles, CA.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of special concern in California. California Department of Fish and Game, Davis.

Myers, J. M., and coauthors. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-35.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and Growth of Klamath River Green Sturgeon (*Acipenser medirostris*). United States Fish and Wildlife Service Project 93-FP-13, Yreka, CA.

Nelson, T. C., and coauthors. 2010. Modern technologies for an ancient fish: tools to inform management of migratory sturgeon stocks. A report for the Pacific Ocean Shelf Tracking (POST) Project.

Newell, R. C., L. J. Seiderer, and D. R. Hitchcock. 1998. The Impact of Dredging Works in Coastal Waters: A Review of the Sensitivity to Disturbance and Subsequent Recovery of Biological Resources on the Sea Bed. Oceanography and Marine Biology 36:127-178.

Nichols, F. H., J. E. Cloern, S. N. Luoma, and D. H. Peterson. 1986. The Modification of an Estuary. Science 231:567-373.

Nichols, F. H., J. K. Thompson, and L. E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. II. Displacement of a former community. Marine Ecology Progress Series 66:95–101.

Nightingale, B., and C. A. Simenstad, Jr. 2001. Dredging activities: Marine issues. Washington State Transportation Center, University of Seattle, Seattle WA 98105.

NMFS (National Marine Fisheries Service). 1997. Investigation of scientific information on the impacts of California sea lions and pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-28.

NMFS (National Marine Fisheries Service). 2005. Green Sturgeon (*Acipenser medirostris*) Status Review Update. NMFS, SWFSC, Santa Cruz.

NMFS (National Marine Fisheries Service). 2006. Biological Opinion for sand mining activities in San Francisco Bay, Santa Rosa, CA.

NMFS (National Marine Fisheries Service). 2008. February 22, 2008, memorandum from Usah Varanasi (Northwest Fisheries Science Center) and Norm Bartoo (Southwest Fisheries Science Center) to D. robber Lohn (Northwest Region, NMFS) and Rodney R. McInnis (Southwest Region, NMFS) evaluating the causes of low 2007 Coho and Chinook Salmon Returns.

NMFS (National Marine Fisheries Service). 2011. Central Valley Recovery Domain – 5-Year Review: Summary and Evaluation of Central Valley Steelhead DPS. National Marine Fisheries Service, Southwest Region, Long Beach, California.

Oliver, J. S., P. N. Slattery, L. W. Hulberg, and J. W. Nybakken. 1977. Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. U.S. Army Corps of Engineers, editor.

Oram, J. J. 2005. Patterns of Temperature, Salinity, and Suspended Particulate Material in San Francisco Estuary: Water Year 2005 in the Context of Previous Water Years. San Francisco Estuary Institute, Oakland, CA.

Osgood, K. E. 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-89.

Popper, A. N. 1997. Sound detection by fish: structure and function in using sound to modify fish behavior at power production and water-control facilities. A workshop December 12-13, 1995. Portland State University, Portland Oregon Phase II: Final Report ed. Thomas Carlson and Arthur Popper 1997. Bonneville Power Administration Portland Oregon.

Popper AN, J Fewtrell, ME Smith and RD McCauley. 2004. “Anthropogenic sound: Effects on the behavior and physiology of fishes.” Marine Technological Science Journal 37: 35-40.

Poytress, W. R., J. J. Gruber, and J. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Quinn, Thomas P. 2005. *The Behavior and Ecology of Pacific Salmon and Trout*. American Fisheries Society. University of Washington Press. 378 pages

Radtke, L. D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon. Pages 115-129 *in* J. L. Turner, and D. W. Kelley, editors. California Department of Fish and Game Fish Bulletin. Ecological studies of the Sacramento-San Joaquin Delta Part II: Fishes of the Delta.

Reiser, D. W., and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Influence of forest and rangeland management on anadromous fish habitat in western United States and Canada. United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; University of Idaho, Idaho Cooperative Fishery Research Unit, PNW-96, Portland.

Ruggiero, P., C. A. Brown, P. D. Komar, J. C. Allan, D. A. Reusser, H. Lee, S. S. Rumrill, P. Corcoran, H. Baron, H. Moritz, J. Saarinen. 2010. Impacts of climate change on Oregon's coasts and estuaries. Pages 241-256 in K.D. Dellow and P. W. Mote, editors. Oregon Climate Assessment Report. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon.

Sandstrom, P. T., T. Keegan, and G. Singer. 2013. Survival and movement patterns of central California coast native steelhead trout (*Oncorhynchus mykiss*) in the Napa River. Environmental Biology of Fishes 96(2-3):287-302.

San Francisco Bay Subtidal Habitat Goals Project (SFBHG). 2010. San Francisco Bay Subtidal Habitat Goals Report – Conservation Planning for the Submerged Areas of the Bay; 50-Year Conservation Plan, www.subtidal.org/report/html

Santer, B.D., C. Mears, C. Doutriaux, P. Caldwell, P.J. Gleckler, T.M.L. Wigley, S. Solomon, N.P. Gillett, D. Ivanova, T.R. Karl, J.R. Lanzante, G.A. Meehl, P.A. Stott, K.E. Talyor, P.W. Thorne, M.F. Wehner, and F.J. Wentz. 2011. Separating signal and noise in atmospheric temperature changes: The importance of timescale. Journal of Geophysical Research 116: D22105.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries, volume 25(2): 149-164.

Schneider, S. H. 2007. The unique risks to California from human-induced climate change. California State Motor Vehicle Pollution Control Standards; Request for Waiver of Federal Preemption, presentation May 22, 2007.

Schoelhammer, D. H. 1996. Factors affecting suspended-solid concentrations in South San Francisco Bay, California. . Journal of Geophysical Research 101:12087-12095.

Schoellhamer, D. H. 2001. Influence of salinity, bottom topography, and tides on locations of estuarine turbidity maxima in northern San Francisco Bay. Pages 343–357 *in* W. H. McAnally, and A. J. Mehta, editors. Coastal and Estuarine Fine Sediment Transport Processes. Elsevier Scienc.

Schoellhamer, D. H. 2002. Variability of suspended-sediment concentration at tidal to annual time scales in San Francisco Bay, USA. Continental Shelf Research 22:1857–1866.

Sebring , S., and coauthors. 2013. Relative Vulnerability of PIT-Tagged Subyearling Fall Chinook Salmon to Predation by Caspian Terns and Double-Crested Cormorants in the Columbia River Estuary. Transactions of the American Fisheries Society 142(5):1321-1334.

Shapovalov, L., and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Fish Bulletin 98.

Scheer JF, J Gokey, VJ DeGhett. 2009. "The incidence and consequences of barotrauma in fish in the St, Lawrence River." North American Journal of Fisheries Management 29:1707-1713.

Shin, Hyeon Ok. 1995. Effect of the piling work noise on the behavior of snakehead (Channa argus) in the aquafarm. J. Korean Fish. Soc. 28(4) 492-502.

Smith, J. J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell, and Pomponio crek estuary/lagoon systems, 1985-1989. Prepared for California Department of Parks and Recreation. Report Interagency Agreement 84-04-324, San Jose State University.

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of Splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126:961-976.

Spence, B. C., and coauthors. 2008. A Framework for Assessing the Viability of Threatened and Endangered Salmon and Steelhead in the North-Central California Coast Recovery Domain U.S. Department of Commerce, National Marine Fisheries Service, Southwest Fisheries Service Center, NOAA-TM-NMFS-SWFSC-423, Santa Cruz, CA.

Spence, B. C., E. P. Bjorkstedt, S. Paddock, and L. Nanus. 2012. Updates to biological viability criteria for threatened steelhead populations in the North-Central California Coast Recovery Domain. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA.

Spence, B. C. G. A. L., R.M. Hughes; R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services Corp., Corvallis, OR.

Stralberg, D., and coauthors. 2011. Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay. PLOS One 6(11).

Tackley, S., R. Stansell, and K. Gibbons. 2008. 2008 Field Report: Evaluation of pinniped predation on adult salmonids and other fishes in the Bonneville Dam tailrace. U.S. Army Corps of Engineers Fisheries Field Unit, Bonneville Lock and Dam. Cascade Locks, OR 97014. 24 pp.

The Nature Conservancy. 2013. California Salmon Snapshots.

Thrush, S. F., J. E. Hewitt, V. J. Cummings, and P. K. Dayton. 1995. The impact of habitat disturbance by scallop dredging on marine benthic communities: What can be predicted from the results of experiments? Marine Ecology Progress Series 129(1-3):141-150.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO2 world. Mineralogical Magazine 72(1):359-362.

UCDavis. 2014. California Fish Tracking Consortium Database acoustic tagging studies on green sturgeon residence.

Van der Veer, H., M. J. N. Bergman, and J. J. Beukema. 1985. Dredging activities in the Dutch Wadden Sea effects on macrobenthic infauna. Netherlands Journal for Sea Research 19:183-190.

Van Eenennaam, J. P., and coauthors. 2006. Reproductive Conditions of the Klamath River Green Sturgeon. Transactions of the American Fisheries Society 135(1):151-163.

Wang, S. NOAA Fisheries. Personal communication, with Mora, E., January 10, 2012 regarding estimates of green sturgeon abundance in Southern DPS rivers in 2010 and 2011.

Waples, R. S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48:124-133.

Westerling, A. L., B. P. Bryant, H. K. Preisler, T. P. Holmes, H. G. Hidalgo, T. Das, S. R. Shrestha. 2011. Climate change and growth scenarios for California wildfire. Climate Change 109(1):445-463.

Wilber, D. H., and D. G. Clarke. 2001. Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management 21(4):855-875.

Wiley ML, JB Gaspin, and JF Goertner. 1981. “Effects of underwater explosions on fish with a dynamical model to predict fishkill.” Ocean Sci. Eng. 6(2):223-284.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update For Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Winder, M., and A. D. Jassby. 2011. Shifts in Zooplankton Community Structure: Implications for Food Web Processes in the Upper San Francisco Estuary. Estuaries and Coasts 34(4):675-690.

Winder, M., A. D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. Ecology Letters 14(8):749-757.

Wright, B. E., S. D. Riemer, R. F. Brown, A. M. Ougzin, and K. A. Bucklin. 2007. Assessment of Harbor Seal Predation on Adult Salmonids in a Pacific Northwest Estuary. Ecological Applications 17(2):338-351.

Wright, S. A., and D. H. Schoellhamer. 2004. Trends in the sediment yield of the Sacramento River, California, 1957–2001. San Francisco Estuary Watershed Science 2(2):1-14.

Yelverton JD, DR Richmond, W Hicks, K Saunders, and ER Fletcher. 1975. The Relationship between Fish Size and Their Response to Underwater Blast. Topical Report DNA 3677T, Defense Nuclear Agency, Washington, D.C.

A. Federal Register Notices Cited

58 FR 33212. National Marine Fisheries Service. Endangered and Threatened Species: Final Rule to Designate Critical Habitat for the Sacramento River winter-run Chinook Salmon. Federal Register 58:33212 June 16, 1993.

59 FR 440. National Marine Fisheries Service. Final Rule. Endangered and Threatened Species: Status of Sacramento River winter-run Chinook Salmon: Reclassified Endangered. Federal Register 59:440 January 4, 1994.

62 FR 43937: National Marine Fisheries Service. Final Rule Listing of Several Evolutionary Significant Units of West Coast Steelhead. Federal Register 62:43937-43954. August 18, 1997.

69 FR 33102. National Marine Fisheries Service. Proposed rule; request for comments. Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids. June 14, 2004.

70 FR 37160. National Marine Fisheries Service. Final Rule. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d)

Protective Regulations for Threatened Salmonid ESUs. June 28, 2005.

70 FR 52488: National Marine Fisheries Service. Final critical habitat designations for 19 West Coast salmon and steelhead ESUs. Federal Register 70:52488–52627. September 2, 2005.

71 FR 834: National Marine Fisheries Service. Final Listing Determinations for Ten Distinct Population Segments of West Coast Steelhead; Final Rule. Federal Register 71:834-862. January 5, 2006.

71 FR 17557: National Marine Fisheries Service. Final Rule: Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 73:17757-17766. April 7, 2006.

71 FR 52084: National Marine Fisheries Service. Endangered and Threatened Wildlife and Plants: Proposed Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 73:52084-52109. September 8, 2008.

71 FR 17386: National Marine Fisheries Service. Proposed Rule: Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 70:1738617401. April 6, 2005.

74 FR 52300: National Marine Fisheries Service. Endangered and Threatened Wildlife and Plants: Final rulemaking to designate critical habitat for the threatened southern distinct population segment of north American green sturgeon. Federal Register 74: 52300-52351. October 2009.

76 FR 50447: National Marine Fisheries Service. Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. Federal Register 76: 50447-50448. August 2011.