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

AUG 24 2016

Refer to NMFS No: WCR-2016-5024

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 reinitation of the San Francisco-Oakland Bay Bridge Seismic Safety Project to address removal of Piers E4-E18 through the use of underwater explosives

Dear Mr. Richards:

Thank you for the California Department of Transportation's (Caltrans) letter of March 31, 2016, 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 E4 to E18 Removal 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 remaining marine foundation piers E4 to E18 through the use of controlled charges (*i.e.* 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 Caltrans' proposal to remove Piers E4 to E18 of the old San Francisco-Oakland Bay Bridge with the use of underwater explosives. This activity is part of the larger San Francisco-Oakland Bay Bridge project, but this method for demolition and bridge removal for these piers was not included in the project description covered in previous consultations. The biological opinion describes NMFS' analysis of the 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 (*Oncorhynchus mykiss*), Central California Coast steelhead DPS (*O. mykiss*), Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*), Central Valley spring-run Chinook salmon ESU (*O. 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 salmonids or green sturgeon species. NMFS also concludes the proposed project is not likely to result in the destruction or adverse modification of the critical habitats for these species. However, NMFS anticipates take of listed salmonids and North American green sturgeon 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.

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,

Ala Lile for

William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Dr. Aaron Allen, US Army Corps of Engineers, San Francisco
Arn Arnborg, CDFW
Copy to file ARN#: 151422SWR99SR190
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

San Francisco-Oakland Bay Bridge (SFOBB) Pier E4 to E18 Removal Project

NMFS Consultation Number: WCR-2016-5024
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:

William W. Stelle, Jr.
Regional Administrator

Date: AUG 2 4 2016

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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/feet
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
RMS	Root-Mean-Square
SEL	Sound Exposure Level
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SPL	Sound Pressure Level
SSC	Suspended Sediment Concentrations
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

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

1.1 Background

NOAA's National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement 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 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.

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[2] 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.

As part of the SFOBB Project, Caltrans has replaced the east span of the SFOBB with a new bridge immediately to the north of the original east span (Figure 1). Caltrans is proposing to use highly controlled explosive charges to dismantle the Piers E4 to E18 marine foundations of the old bridge (Figure 2) as part of the Pier E4 to E18 Removal Project.

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[1] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR-2016-5024

2 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.

Figure 1. SFOBB East Span Seismic Safety Project Map (Caltrans 2016a).

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.

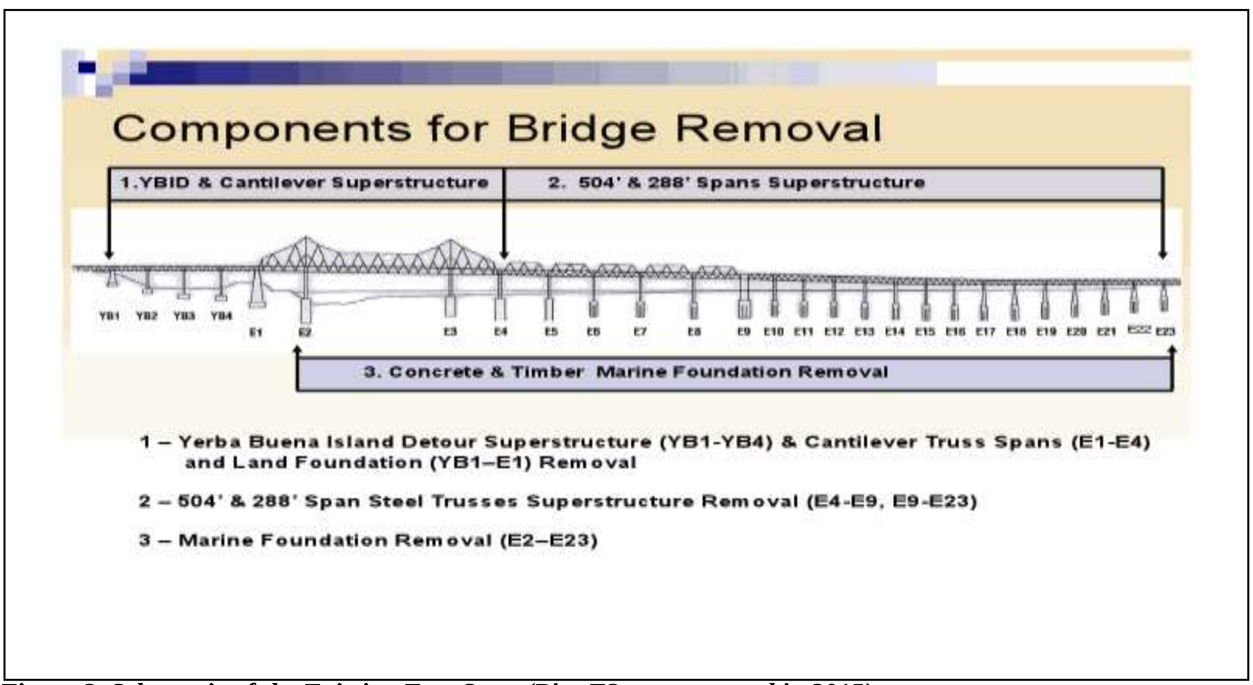


Figure 2. Schematic of the Existing East Span (Pier E3 was removed in 2015).

Dismantling the cantilever superstructure and YBI Detour was completed in June 2015.

Ongoing work on this phase of the project also involves dismantling the terrestrial piers and bents on YBI while restoring and improving the project site and adjacent United States Coast Guard (USCG) station. Dismantling of the SFOBB original east span began in late 2013. Removal of the 504-foot and 288-foot spans started in mid-2015, and is ongoing. Demolition work for the marine foundation removal work began in May 2015.[3] Controlled blasting was used to implode the in-water portion of Pier E3 on November 14, 2015. All debris resulting from the controlled blast was removed to below mudline, and the Pier E3 Demonstration Project was completed in December 2015. Pier E3 was the first marine foundation chosen for dismantling, and it was selected to demonstrate the effective use of controlled blasting to remove the marine foundations. The next phase of marine foundation removal would incorporate the experience from the Pier E3 Demonstration Project to remove Piers E4 to E18 using both mechanical and controlled blasting methods.

1.2 Consultation History

On October 31, 2001, formal section 7 consultation between NOAA's National Marine Fisheries Service (NMFS) and the Federal Highway 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, 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 reinitiated twelve times (2003 through 2016) with NMFS to address proposed changes to the project, and to address impacts of the project on Federally-listed species. The most recent consultation was completed in August 2015. 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 construction and 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, and most recently the removal of only Pier E3 with controlled charges. The construction of the new bridge was completed in 2013.

In 2014, Caltrans amended the SFOBB Project’s existing permits and consulted with NMFS to cover the use of controlled implosion as a removal method for Pier E3. Consultation history for the period of March 27, 2014 and June 2015 is covered in the August 2015 BO (NMFS 2015). Since the pilot project was considered a successful means for pier removal, Caltrans is seeking reinitiation of consultation for the use of controlled charges to dismantle the remaining Piers, E4

3 The effects of demolition work underway in May 2016 were analyzed in prior biological opinions, most recently the February 6, 2012 and August 27, 2015 biological opinions for the project.

to E18. These effects, and effects from the remaining demolition work, will be considered in this opinion for salmonids, green sturgeon, their critical habitats and EFH.

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 results of the Pier E3 Demonstration Project and the proposal to remove the remaining marine foundations during the Pier E4 to E18 Removal Project. By letter dated March 31, 2016, Caltrans requested reinitiation of consultation for the SFOBB Project to address the use of controlled charges (explosives) to remove Piers E4 to E18 of the old SFOBB 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. This reinitiation request was received by NMFS on April 6, 2016.

Several meetings, telephone conference calls, and e-mail communications were exchanged between January 2016 and June 2016 regarding the proposed Pier E4 to E18 Removal Project, blast plan, attenuation methods and required hydroacoustic monitoring. NMFS requested additional information via conference call and emails on May 3 and June 22, 2016, and received the additional information by e-mail on May 16, June 14, and June 24, 2016. Consultation was initiated on June 14, 2016.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Caltrans is proposing changes to the remaining construction work for the SFOBB East Span Seismic Project. Specifically, Caltrans proposes to remove Piers E4 through E18 via highly controlled charges. Removal of the original east span, including the marine foundations, is required to satisfy regulatory requirements of the SFOBB Seismic Safety Project. Implosion of Piers E4 through E18 would follow the Pier E3 Demonstration Project completed in November 2015. Piers E4 and E5 would become the next marine foundations available for immediate removal in the dismantling process.

The conventional bridge dismantling methods which were analyzed in the 2015 BO employ large cofferdams with extensive amounts of associated pile driving and dewatering, occurring over multiple seasons. Caltrans instead proposes to remove Piers E4 to E18 with the use of controlled to implode them into their open cellular chambers below the mudline. The use of controlled charges is expected to reduce the extent and duration of environmental impacts compared to currently permitted conventional bridge dismantling methods. 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 SFOBB Pier E4 to E18 Removal Project is expected to last approximately 21 months, over the course of three seasons, beginning in summer 2016 and ending by December 15, 2018.

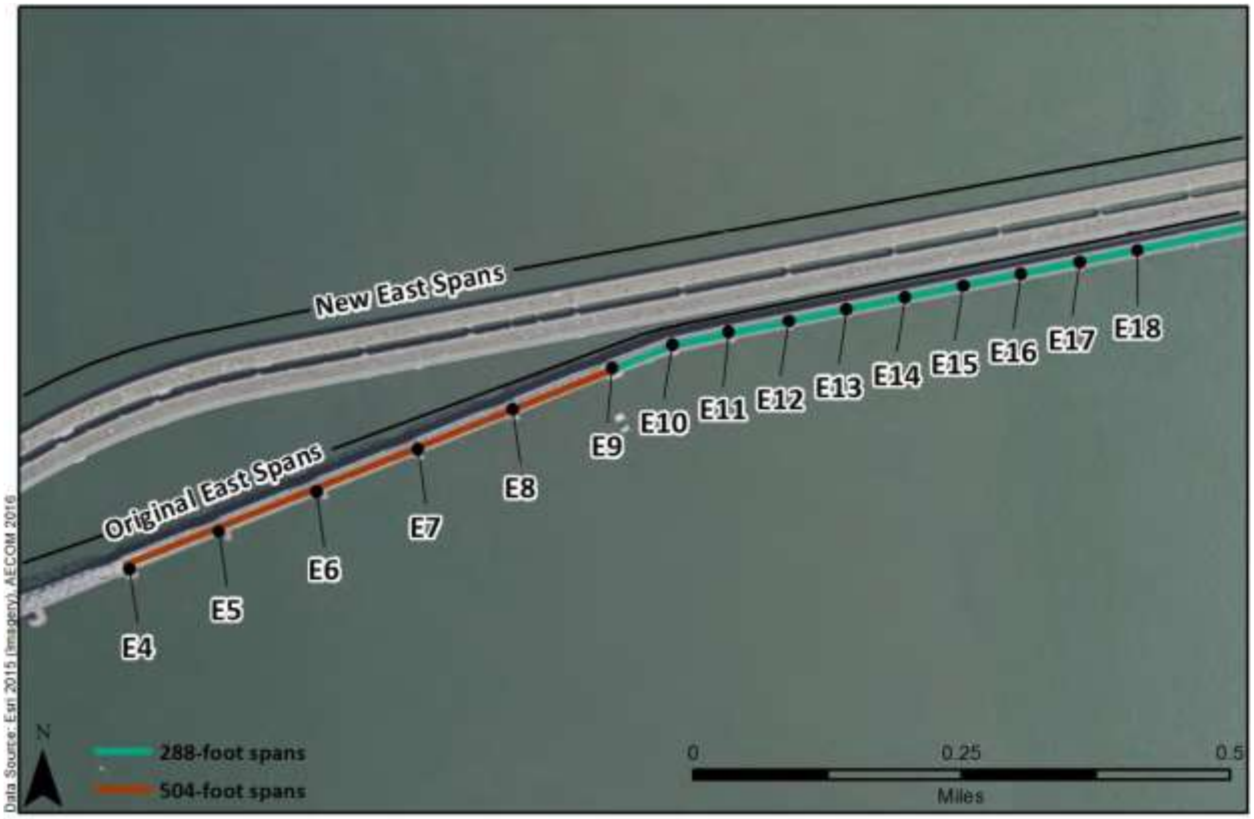
The implosion of the piers will be confined to the months of September through November each year. Two piers (E4 and E5) will be removed in 2016, six piers (E6 to E11) will be removed in 2017, and the remaining seven piers (E12 to E18) are expected to be removed in 2018. The maximum number of piers removed in a single year will be seven. Removal of the original truss, suspended span, and supporting tower on Piers E4 through E18 (all of which are located above-water) would occur before the start of the marine foundation removal, including the proposed implosions. Piers E4 through E18 would be removed through a controlled implosion, lasting one to five seconds each. To help minimize impacts to biological resources, the controlled implosions will be conducted during an ebb tide. Some clean-up and in-water site management operations are expected to continue additional weeks after each controlled blast and be completed by mid-December each year.

The Pier E4 to E18 Removal Project activities include: 1) Mechanical Dismantling of Pier E4 to E18, 2) Use of Controlled Charges for Test Blasts and Pier Implosion, 3) Sound Pressure Attenuation through use of a Blast Attenuation System (BAS), and 4) Management and Removal of Debris. The methods for these activities, and the other remaining activities to remove the old bridge, are described below, beginning with locations and descriptions of Pier E4 through E18.

1.3.1 Locations and Description of Piers E4-E18

The proposed work to remove the marine foundations of the SFOBB original east span occurs within the jurisdictions of the City and County of San Francisco (CCSF) and the City of Oakland in Alameda County. Piers E4 and E5 are located within CCSF jurisdiction. Pier E6 straddles the border that delineates the CCSF from the City of Oakland. Piers E7 to E18 are located in the City of Oakland. All piers are located between the OTD and YBI (Figure 1), and are situated south of the SFOBB new east span bridge (Figure 3).

Piers E4 to E18 are located on the SFOBB original east span, west of the OTD and east of YBI. The approximate water depth varies by pier location.



Source: ESRI 2015 (imagery); compiled by AECOM in 2016
Figure 3. Locations of the Original East Span Marine Foundations Piers E4 to E18 (Caltrans 2016a).

Piers E4 to E18 were constructed to support the steel superstructure of the SFOBB original east span. The piers are cellular concrete structures. None of the piers reaches down to bedrock. Piers E4 and E5 differ from the other piers proposed for removal because they are concrete caissons that are buried deep into the mud and are not supported below by timber piles. Similar to Pier E3 (removed in 2015), they are cellular caissons with large voids that would remain below mudline, which would be available for depositing debris resulting from dismantling.

Piers E6 to E18 are each supported by timber piles (all piles are untreated Douglas fir piles). A concrete seal was poured on top of each pile set. Concrete seals were poured well below the surrounding mudline elevation, approximately 10 to 20 feet (3 to 6 meters), during construction, with the exception of Pier E6, which was poured up to the mudline elevation during construction. On top of the concrete seals, a flat, unreinforced concrete slab was poured to support the cast-in-place concrete piers.

<u>1.3.2 Pier E4 to Pier E18 Removal Overview</u>

Caltrans proposes removing each of the concrete marine foundations, Piers E4 to E18, in two phases. The first phase will use mechanical dismantling and the second phase will use controlled blasting methods (similar to what was used for Pier E3) for removal followed by debris management to removal limits on the Bay substrate. Limits of removal were determined by the

U.S. Coast Guard and the Corps of Engineers at each location and would result in removal to three feet below the mudline. The portions of the piers that are found above water would be removed using the technique previously authorized for mechanical dismantling. Caltrans proposes to use the same controlled blasting methods used for Pier E3, to implode the in-water portion of Piers E4 and E5 into their open cellular chambers, where resulting rubble would be buried below mudline with the sediment filling the voids. Since Piers E6 to E18 are not cellular caissons like Piers E4 and E5, they will be removed differently. These piers are large concrete structures that extend deep below the mudline, supported by hundreds of timber piles. The timber piles and concrete seals courses that are below approved removal limits would remain in place. Rubble that mounds above the determined debris removal elevation limits of Piers E6 to E18 would be removed off-site for disposal.

A BAS similar to that used for the Pier E3 implosion would be used during all future controlled blasting events to minimize potential impacts on biological resources in the Bay.

1.3.3 Removal of Piers E4 to E18

Each pier would be removed using the following two phases: 1) pre-blast activities including mechanical dismantling of the fender system (Piers E4 and E5 only), removing the pier cap and concrete pedestals, installing and testing the BAS, and 2) drilling the boreholes, installing charges, activating the BAS, imploding the pier, and managing the remaining debris.

For all piers, the concrete pedestals and pier cap will be removed by mechanical means, using tools including but not limited to, the use of torches and excavators mounted with hoe rams, drills, and cutting tools to break the concrete structure into pieces. Concrete rubble and rebar will be managed using excavators and cranes that will be mounted with buckets. Throughout concrete dismantling operations on each pier, support platforms will be installed to provide a working surface for the excavators to dismantle the upper portion of the piers. The support platforms will consist of timber crane mats. Timber crane mats covering pier areas that have been removed down to mechanical dismantling removal limits (e.g., down to the water line) will be removed and replaced with less substantial timber crane mats, to provide access for bore hole drilling operations and to minimize flyrock during controlled blasting. The exposed interior cell walls, buttress walls, and outside walls will be drilled from the top down, to remove concrete and create boreholes to just below three feet below the mudline for each pier. Boreholes that are drilled in areas that are inundated with water (*i.e.,* to the buttress walls and concrete slabs) will be done using a drill bit working within a tubular casing for guidance and to provide containment during in-water work. Monitoring will be performed to minimize and avoid impacts on water quality during this activity. A debris catchment system will be in place to prevent concrete debris from discharging into the Bay during dismantling operations.

Mechanical dismantling is expected to start in July 2016 on Piers E4 and E5, following removal of the overhead 504-foot truss sections and steel support towers that are part of the 504/288 dismantling work. The removal of Piers E4 and E5 would be similar to what was done for Pier E3 (described and analyzed in the 2012 and 2015 BOs). Steps to remove the marine foundations would include removing the timber, steel, and pile-supported fender system that surrounds each pier (Piers E4 and E5 only), dismantling the concrete pedestals and concrete pier cap by mechanical means, and drilling vertical boreholes where the charges would be loaded for controlled blasting. Once the charges are loaded into the boreholes, controlled blasting removal would be accomplished using hundreds of small charges, with delays between individual charges. Each controlled blast sequence would last approximately one to five seconds, depending on the pier being removed. The controlled blast removals have been designed to remove each pier to a minimum three feet below the mudline elevation that occurs outside each pier's scoured pit.

Mechanical dismantling of Pier E5 would include a step that was included in the removal of Pier E3 but is otherwise unique from the remaining piers proposed for removal. The lower caisson cells of Pier E5 on the east and west face of the lower segment of the pier are covered with pre-cast concrete slabs. To ensure that the lower caisson chambers would be open to receive rubble during the controlled implosion of the pier, these slabs would be mechanically removed by breaking them with a modified steel pile (spud-pile) that would be attached to and controlled by a barge-mounted crane. The controlled drop would bring the pile down on each slab. The weight of the modified pile would cause each concrete slab to shatter and fall into the caisson cells.

For Piers E4 and E5, all concrete rubble from the mechanical dismantling will be placed into exposed cells of the caissons and is expected to fall below the mudline and become buried with sediment for disposal. For Piers E6 to E18, all concrete rubble from mechanical dismantling of concrete pedestals will be removed off-site for disposal. Rubble will be loaded onto receiving barges. The barges will be moved to Pier 9 in the Port of Oakland, where concrete rubble and rebar will be removed from the barges onto land, to be sorted and disposed at an approved upland facility. Pier caps covering the central chambers of these piers will be dismantled last. They will be broken with a hoe ram and will remain in the hollow void during controlled blasting. Schematics for each pier are provided in the Biological and Essential Fish Habitat Assessment (Caltrans 2016a).

1.3.4 Drilling Boreholes

Once the piers have been dismantled to the mechanical dismantling elevation, access platforms will be installed to support drilling equipment while exposing the top of the interior cells and outside walls. Drilling holes for underwater buttress walls on Pier E5 and Pier E9 will be done by the same method that was used for the buttress wall of Pier E3. Divers will cut notches into the buttress walls to guide the drill and will install the conduit to the work platform on top of the pier. The drilling will be done within the casings from the work platform. The boreholes will vary in diameter and depth, designed to provide optimal efficiency in transferring the energy created by the controlled charges

1.3.5 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. Individual cartridge charges, using electronic blasting caps versus pumpable liquid blasting agents, have been selected to provide greater control and accuracy, and will allow for a refined blast plan that efficiently breaks concrete while minimizing the amount of charges needed. Individual charge weights would be approximately 20 to 35 pounds (9 to 16 kilograms), and the total charge weight for each controlled blast event would vary from approximately 2,132 to 15,800 pounds (967 to 7,167 kilograms). Depending on the location, size, and removal limit of the pier to be removed, the total number of individual charges to be used would range from approximately 100 to 455. Charges would be arranged in different levels (decks) and would be separated in the boreholes by stemming. Stemming is the insertion of inert materials (*e.g.*, sand or gravel) to insulate and retain charges in an enclosed space (Caltrans 2016a). Stemming allows for more efficient transfer of energy into the structural concrete for fracture, and further reduces the release of potential energy into the surrounding water column. Each controlled blast sequence would last several seconds (one to five). The exact time duration will depend on the size and structure of the pier being removed.

Controlled blasting of Piers E4 and E5 would result in the implosion of the piers, with the rubble falling into the open caisson cells. The concrete on Pier E6 will be removed by blasting down through the concrete slab and the top three feet of the concrete seal. Site conditions require that Pier E6 be blasted further down into the structure in order to remove the upper three feet of concrete seal to obtain the approved elevation. Any remaining concrete seal and timbers would not be removed but remain in place below the mudline. Pier E7 will be removed in a similar manner to E6, except not through the concrete seal. Concrete removal for Piers E8 to E18 will entail blasting down through the concrete cellular structure but not through the concrete slab, seal, and timber piles below. The remaining concrete seals and timber piles will not be removed but will remain below the mudline and buried.

<u>1.3.6 Test Blasts</u>

Before each pier implosion, test blasts may be conducted within the operating BAS in order to ensure the hydroacoustic monitoring equipment is properly triggered and functional before each pier implosion event. Test blasts will consist of smaller charges, with an approximate charge weight of 18 grains (0.0025 pound). The test charge would be placed along one of the longer faces of the pier and inside the BAS while it is operating. Caltrans assumes a maximum of two test blasts will be required for each pier to adequately ensure the monitoring systems and BAS are properly calibrated and functioning properly, as well as to rehearse other blast activities. Acoustic measurements during the test blasts 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 hydroacoustic measurement systems prior to the implosion. The BAS would be in operation during all tests.

<u>1.3.7 Blast Attenuation System (BAS)</u>

The BAS is specifically designed to minimize noise and pressure impacts generated by the controlled blasts. The BAS that will be used at Piers E4 to E18 will be similar to the system developed and used for the Pier E3 Demonstration Project. The BAS is a modular system of pipe manifold frames, placed around each pier and fed by air compressors to create a curtain of air bubbles (Figure 4). The BAS will be activated before and during implosions. The BAS is intended to minimize noise and pressure waves generated during each controlled blast to minimize potentially adverse effects on biological resources that may be nearby. Each BAS frame is approximately 50.5 feet (15.4 meters) long by 6 feet (1.8 meters) wide. The BAS design details and specifications used for the implosion of Pier E3 are provided in Appendix I of the Biological Assessment (Caltrans 2016a).

Before installing the BAS, Caltrans will prepare the substrate surrounding each pier to ensure proper placement of the frames by removing any debris on the Bay floor that may prevent flush contact with the substrate. Each BAS frame would be lowered to the bottom of the Bay by a barge-mounted crane and positioned into place. Divers will be used to assist frame placement and connect the air hoses to the frames. Based on location around each 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 each pier. 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 (%). Caltrans expects the system will provide approximately 80% attenuation, or better, based on past experience with similar systems during controlled blasting, including during the Pier E3 Demonstration Project. The complete BAS would be installed and tested during the weeks leading up to each controlled blast. The BAS test parameters will include checking operating levels, flow rate and a visual check to determine that the system is operating correctly. Each BAS frame will be fed by an individual compressor mounted on a barge. This will require multiple compressors located on flexi-float barges situated around each pier. Each barge will be temporarily anchored to maintain their position. Once the controlled blast events have been completed, the contractor will demobilize the BAS and all associated equipment. A complete description of the BAS is provided in Appendix I of the Biological Assessment for the project (Caltrans 2016a).

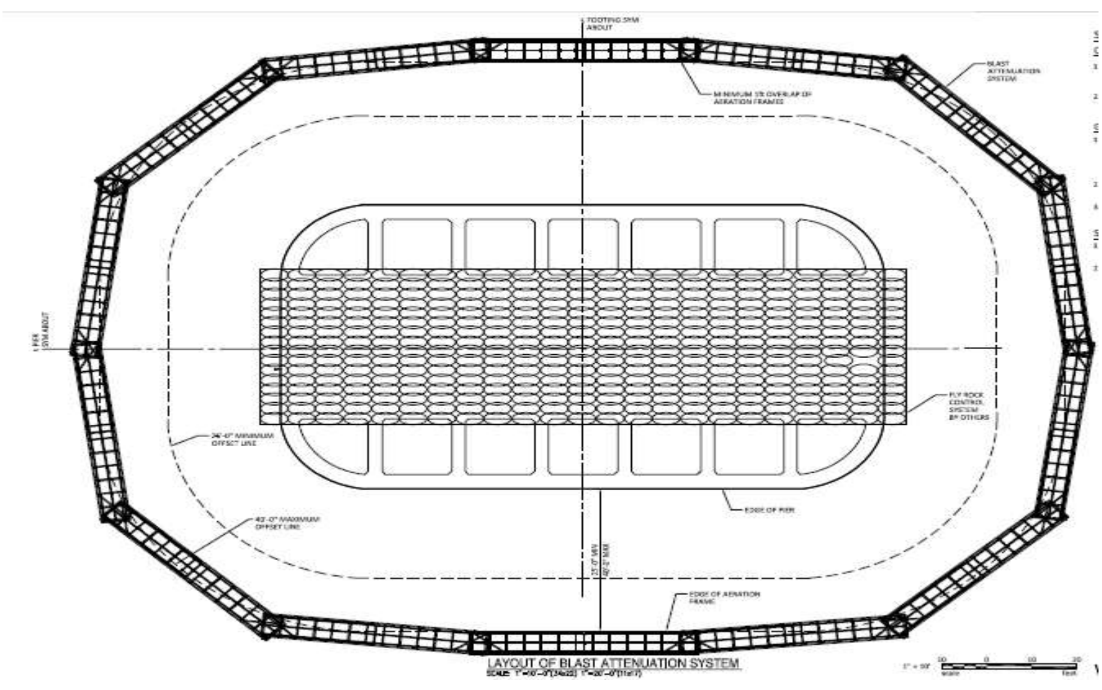


Figure 4. The Blast Attenuation System Layout (Caltrans 2016a, Appendix I).

1.3.8 Management and Removal of Debris

Following the completion of dismantling and controlled blasting activities, construction crews will remove all associated equipment, including barges, compressors, the BAS and blast mats.[4] For Piers E4 and E5, Caltrans expects a small portion of rubble may fall outside the pier footprint and not into the caisson cells. This material will be removed from the Bay floor and deposited into the caisson cells to be entombed when the voids fill with sediment. Any portions of the piers that do not break apart during the blasts and remain above the removal limits will be demolished by mechanical means. This may require the use of equipment described previously, including hydraulic crushing or grinding machinery and/or diver-operated jackhammers. Any rubble remaining after the controlled blasts of Piers E6 to E18 will be removed or excavated from the substrate to the current scour line elevation for each pier by barge mounted cranes with clamming buckets.

1.3.9 Monitoring and Avoidance and Minimization

Caltrans will implement the following measures in addition to the BAS to monitor and avoid or minimize effects to federally-listed species and their habitats:

1. Hydroacoustic Monitoring and Implosion Event Reporting. Actual efficiency during the controlled blasts will be evaluated through hydroacoustic monitoring. The measurements will be used to determine calculated distances to reach sound pressure thresholds for fishes, to verify sound propagation modeled for the blast event, and to ensure incidental take limits are not exceeded during each controlled blast event. Following each individual implosion event, Caltrans will provide NMFS and the California Department of Fish and Wildlife (CDFW) with a summary of preliminary monitoring results as soon as they are available. Final reports, including monitoring results and lessons learned will be submitted to the agencies for review. Lessons learned from each implosion event will be incorporated into the monitoring efforts for subsequent pier implosions.

2. Seasonal Avoidance: To avoid project effects to the highest concentrations of ESA-listed fish species, the Pier E4 to E18 Removal Project activities will occur within the seasonal work window of June 1st – December 15th, with the use of controlled charges for Piers E4 to E18 only occurring September 1 to November 30th when the vast majority of the ESA-listed species are not likely to be present or only present in extremely low numbers. All other pier and debris removal (*e.g.*, mechanical and dredging, etc.) activities will occur June 1 through December 15th.

3. During mechanical dismantling, Caltrans will monitor water quality and would employ best management practices to prevent inadvertent discharges into the Bay.

4. Bird Predation Monitoring/Fish Salvage. For the project, several bird predation

[4] Blast mats are thick rubber and wood mats placed over the marine foundation during the implosion in order to reduce the amount of fly-rock and debris generated during the explosions.

monitors will be positioned to record bird predation activity before, during, and after Pier E4 through E18 implosions. 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 CDFW within 72 hours of each pier implosion. If feasible, any dead green sturgeon, salmonids, or longfin smelt collected during monitoring will be preserved for transfer to NMFS or CDFW. A final bird predation monitoring report will be provided to the agencies for review and approval prior to the implosions.

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 Pier E4 to E18 Removal Project, all project-related equipment (barges, cranes, piles, BAS, *etc*.) will be placed and/or staged outside the eelgrass ESA buoys.

6. Trash Control. All food-related trash items such as wrappers, cans, bottles, and food scraps will be disposed in closed containers and removed at least once a day from the work area.

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

8. Water Quality Monitoring. Detailed water quality monitoring guidelines will be included in the SFOBB Piers E4 to E18 Removal Project Monitoring Plan. Turbidity, pH, dissolved oxygen, temperature, and conductivity will be monitored during mechanical dismantling activities, drilling activities, the controlled implosion, and post-implosion debris removal activities. Monitoring will be conducted in accordance with methods and standards outlined in the Water Quality Self-Monitoring Program required by 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 the project activities do not exceed 50 NTU, or result in an incremental increase greater than 10% of the background NTU at a distance greater than 100 feet (30 meters) from the activity. EFH monitoring will be conducted when construction activity occurs within 3,200 feet (1,000 meters) of an eelgrass bed or sand flat, or as required by the RWQCB.

9. Storm Water Pollution Prevention Plan. A RWQCB approved SWPPP for the project must be adhered to for all project-related activities; appropriate BMPs will be used for all activities with potential to impact water quality. Water quality monitoring will be undertaken to ensure adherence to the SFOBB Project 401 Certification and Waste Discharge Requirements, and the San Francisco Bay RWQCB Basin Plan.

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.

1.3.1.1 Remaining Project Activities

The new bridge construction was completed in 2013. The remaining activities include dismantling of the old, existing east span of the bridge, including the removal of Piers E4 to E18. 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 and August 2015 BOs. The only activity not analyzed in the previous consultations was the use of controlled explosives for removal of Piers E4 to E18. The remaining bridge removal activities are:

- 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 activities, the YBITS 2 removal, started in late 2013 and involved the dismantling of the YBI Detour structure and Cantilever Span. Removal of the cantilever was completed in 2015, the remaining components are expected 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 sections 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. The removal of the marine foundations is the last phase, and will be completed by December of 2018. Pier E3 removal was completed in December 2015, the remaining Piers (E4 to E18) are part of this final phase, and have been selected for removal with the use of controlled charges. Removal of the above-water pier structures (*e.g.,* wooden fender systems and pier caps, *etc*.) will begin in July 2016.

1.3.1.2 Interrelated and Interdependent Activities

“Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02). No interrelated or interdependent activities have been identified by NMFS for this project.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The SFOBB Project site, including the area around the bridge piers and the area necessary to accommodate construction-related equipment such as work barges and cranes, is located in San Francisco Bay, between YBI and Oakland. For the remaining activities of the SFOBB, including the removal of Piers E4 to E18, NMFS defines the action area to be: 1) the portions of North, Central, and South San Francisco Bay subject to sound pressure waves around the piers, determined by hydroacoustic analyses corresponding to distances from pile driving for falsework construction and from Piers E4 to E18 subject to impulsive sound pressure thresholds for fish, and 2) the Bay substrate and water column surrounding the old bridge and pier E4 to E18 subjected to temporary elevated turbidity levels. These areas include locations affected by mechanical disturbance (from bridge dismantling), high underwater sound levels, turbidity, and all other project effects. 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 shows the action area. Figure 7 shows extent of the sound field for E4 and E5. Because these are the largest marine foundations, the area of impact for these two piers represents the greatest extent of area expected to be impacted by high sound levels from the implosions for all of the piers over the duration of the project. The distances to reach respective thresholds and additional figures for each pier (E4 to E18) are provided in Appendix H of the Biological Assessment for the project (Caltrans 2016a). As the project moves closer towards the Oakland Touchdown (towards Pier E18, and closer to shore, the sound field shown (concentric rings) in Figure 7 will also move towards the shoreline, extending into shallower water and up onto the shoreline.

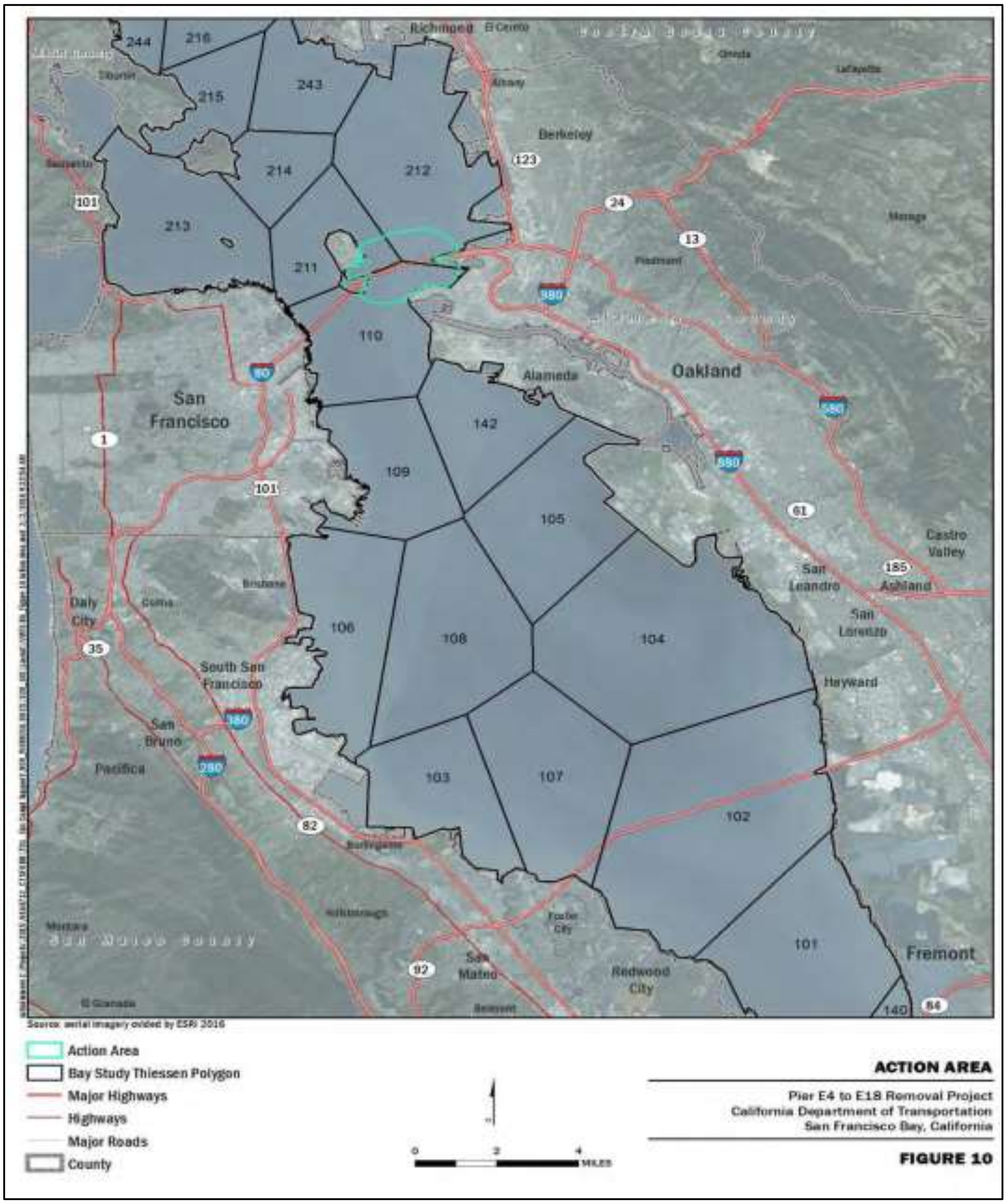


Figure 6. Action Area and Bay Study Sample Polygons (Caltrans 2016a)

For Piers E4 to E18, the entire extent of the sound field covers 1,477 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 4,752 feet from the piers during each implosion. While this distance reflects the maximum distance subject to sound pressure thresholds (and includes any areas affected by other remaining SFOBB activities), a smaller area of approximately 106 acres, extending a radial distance of 1,165 feet (for all piers) would be temporarily subjected to the 206 dB peak and 187 dB cumulative sound exposure level (cSEL) thresholds for onset of injury to fish two grams or larger. Due to their life histories and size when they are present in the Bay (see Baseline, section 2.3), no ESA-listed fish species within the action area are expected to be smaller than two grams.

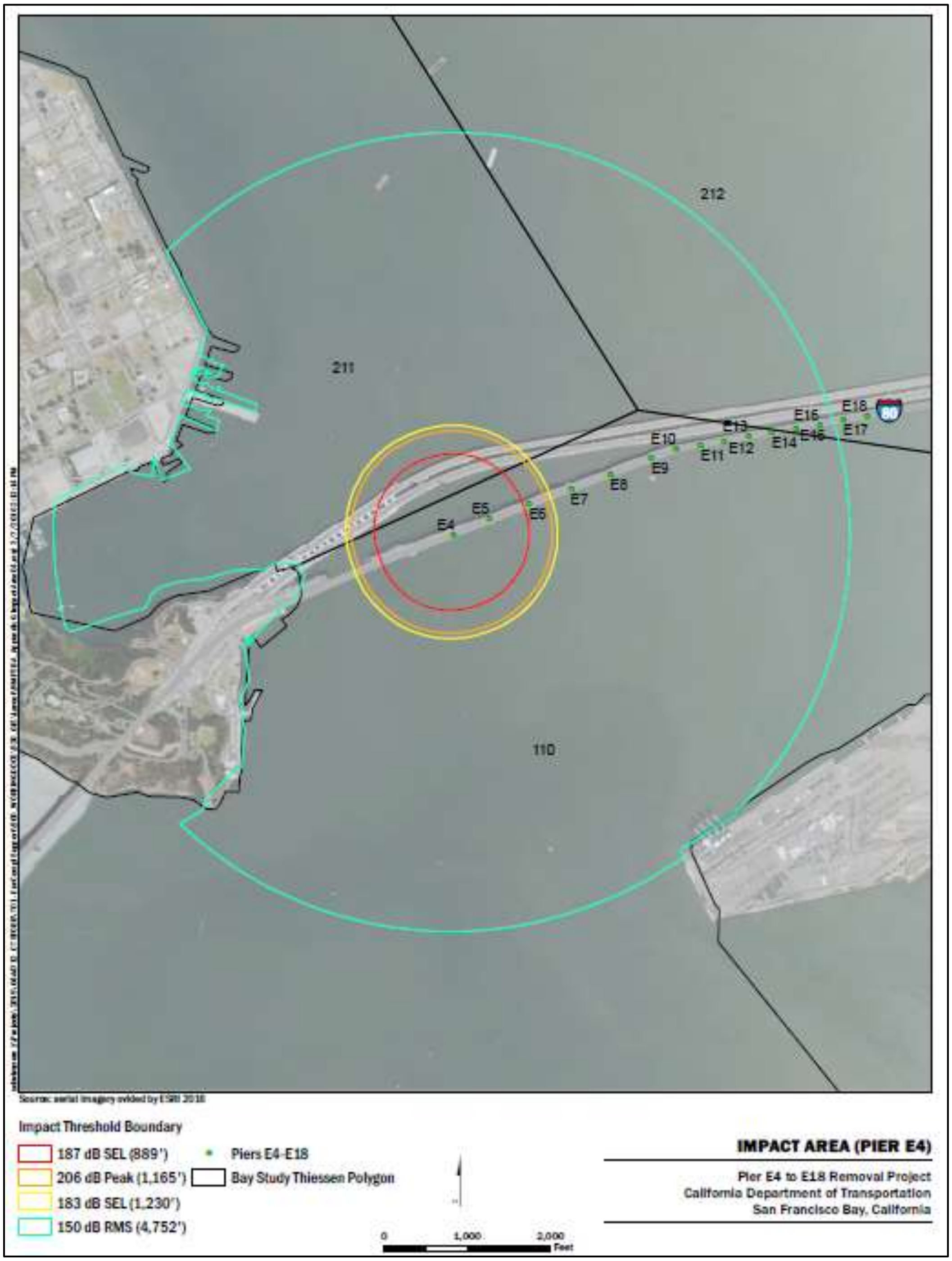


Figure 7. Sound Field for Pier E4 and E5, and Distances to reach sound pressure thresholds for Piers E4 and E5 (Caltrans 2016a, Appendix H).

The entirety of the action area is within the San Francisco Bay. No terrestrial communities are associated with the proposed Pier E4 to E18 Removal Project, and 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 during dismantling sections of the existing bridge.

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

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

2.1 Analytical Approach

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

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

Species and critical habitat status are discussed in section 2.2 of this biological opinion.

2.2 Rangewide Status of the Species and Critical Habitat

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

In designating critical habitat, NMFS considers, among other things, the following requirements of the species: 1) space for individual and population growth, and for normal behavior; 2) food, water, air, light, minerals, or other nutritional or physiological requirements; 3) cover or shelter; 4) sites for breeding, reproduction, or rearing offspring; and 5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species (50 CFR 424.12(b)). The designations of critical habitat considered here use the term primary constituent element or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this biological opinion, NMFS uses the term PBF to mean primary constituent element or essential feature, as appropriate for the specific critical habitat.

This biological opinion analyzes the effects of the proposed San Francisco-Oakland Bay Bridge Piers E4 to E18 Removal 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);

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 and thus is not analyzed in this biological opinion.

2.2.1 Species Description, Life History, and Status

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). This decision was reaffirmed in the 2010 review. 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). NMFS reevaluated the status of this hatchery stock in the most recent review, and concluded that it should remain part of the CV spring-run Chinook salmon ESU (NMFS 2016a).

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. While some conservation measures have been successful in improving habitat conditions for the, fundamental problems with the quality of remaining habitat

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

persist (Lindley *et al.* 2009, Cummins *et al.* 2008, and NMFS 2014). Thus habitat that supports the ESU remains in a highly degraded state. Overall, major habitat expansion and restoration for CV spring-run Chinook salmon has not occurred as of the most recent review (NMFS 2016a), therefore, the loss of historical habitat and degradation of remaining habitat continue to be major threats to the CV spring-run Chinook salmon ESU. Although some 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 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. 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 2011 status review concluded the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review (Williams *et al.* 2011). More recent reviews indicate an overall increased escapement rate between 2012-2014, although abundance of the ESU decreased dramatically in 2015. Until 2015, Mill Creek and Deer Creek populations both improved from high extinction risk in 2010 to moderate extinction risk due to increases in abundance, and because Butte Creek continued to meet the criteria for low extinction risk. This may be due in part to increased flows since 1996, which allowed for natural repopulation of Battle Creek, which supports a historical independent population in the Basalt and Porous Lava diversity group. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the CV spring-run Chinook salmon population in Clear Creek has been increasing, and currently meets the moderate extinction risk score (NMFS 2016a). The most recent declines in 2015 are partially attributed to the two drought periods the ESU has experienced over the past decade. From 2007 to 2009, and now 2012 to 2015, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon (Michel *et al.* 2015). Additionally, the effects of warm ocean conditions, coupled with drought years on the juvenile life stage will not be fully realized by the viability metrics until they manifest between 2015 through 2018, with potential low run size returns (Williams *et al.* 2016). The low returns of 2015 indicate this is already occurring. Information available since the 2010 status review indicates the status of the CV spring-run Chinook salmon ESU has probably improved due extensive restoration, and increases in spatial structure with historically extirpated populations trending in the positive direction. The three independent populations show improvements in the moderate and low risk of extinction criteria, but the recent declines in the dependent populations, evident through high pre-spawn and egg mortality during the 2012 to 2015 drought, and uncertain juvenile survival during the drought, and ocean conditions, as well as the level of straying of FRH spring-run Chinook salmon to other CV spring-run Chinook salmon populations are all causes for concern for the long-term viability of the CV spring-run Chinook salmon ESU. Thus the moderate improvements are not enough to warrant the delisting of the ESU. Based on this information, NMFS has chosen to maintain the threatened listing for this species.

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).

New steelhead escapement information in Mill Creek is now available at Ward Dam via a video monitoring by CDFW (NMFS 2016b). Adult steelhead moving upstream have been counted since the 2008-09 season. Numbers of adults have ranged from 60 to 237, with an average of 142 over the last six years (CDFW 2015). These fish all appear to be naturally produced. The increase in numbers over the last few years is likely due to recent low flows associated with recent drought years, which improves the ability to count fish at this station.

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. 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 recommended reviewing CV steelhead status again in 2-3 years, (instead of the normal 5 years) if species numbers do not improve (NMFS 2011). The most recent status review indicates the status of CV steelhead appears to have changed little since the 2011 review. At that time the TRT concluded that the DPS was in danger of extinction. There still remains a lack of data on the status of wild populations, but in the last few years several hatcheries in the Central Valley have experienced increased returns (NMFS 2016b). Additionally, a slight increase in the percentage of wild steelhead in salvage at the south Delta fish facilities has occurred, and the percentage of wild fish in those data remains much higher than at Chipps Island. Ward Dam also shows that Mill Creek may support one of the best wild steelhead populations in the Central Valley, even though the population is still greatly r3educed from levels encountered in the 1950's and 60's. Restoration and dam removal efforts in Clear Creek continue to benefit CV steelhead, although the catch of unmarked (wild) steelhead at Chipps Island is still less than five percent of the total smolt catch, indicating natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain (NMFS 2016b).

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).

Viability assessments from 2008 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 2011 status review by the Williams *et al.* (2011) concluded that steelhead in the CCC steelhead DPS remains "likely to become endangered in the foreseeable future", and while data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since publication of the last viability assessment (Spence 2016). On December 7, 2011, NMFS affirmed no change to the determination that the CCC steelhead DPS is a threatened species, as previously listed (NMFS 2011, 76 FR 76386). In April 2016, NMFS issued its 2016 5-Year Review: Summary & Evaluation of Central California Coast Steelhead (NMFS 2016c) and recommended CCC steelhead DPS remain listed as threatened.

Critical habitat was designated for CCC steelhead on September 2, 2005 (70 FR 52488) and includes PBFs 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 PBFs 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., personal communication January 2012). However, it is important to note that this estimate may include some white sturgeon, and movements of individuals in and out of the survey area confound these estimates. Given these uncertainties, caution must be taken in using these estimates to infer the spawning run size for the Sacramento River, until further analyses are completed.

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

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

2.2.2.3 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).

2.2.2.4 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.

2.2.2.5 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).

2.2.2.6 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.

2.2.2.7 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.

2.2.2.8 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).

2.2.2.9 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).

2.2.2.10 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).

2.2.2.11 Global Climate Change

Another factor affecting the rangewide status of threatened Southern DPS of North American green sturgeon, threatened CCC and 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 and listed green sturgeon to date are likely fairly minor because natural climate factors likely still drive most of the climatic conditions these fishes experience, and many of these factors have much less influence on 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" 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 Pier E4 to E18 Removal 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 328 feet (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 consists of largely open water (pelagic) habitat along with subtidal and intertidal habitats closer to YBI and Treasure Island. Although the Central Bay is the deepest basin, water depth at the location of the piers ranges between 49 feet (15 meters) for Pier E4 and 16 feet (5 meters) for Pier E18, with Piers E7 through E18 located in less than 33 feet (10 meters) of water. Within intertidal zones, eelgrass (*Zostera marina*) beds were documented in 2015, at the Emeryville flats and Coast Guard Cover along the southeast side of YBI. Eelgrass beds also occupy the subtidal zone. No eelgrass beds were identified along the northeast and east sides of Treasure Island and Clipper Cove. Subtidal habitats near Piers E4 to E18 are classified as soft mud and sandy bottoms with occasional rocks and cobbles, which vary in composition depending on distance from the shore (CCSF 2010). Eelgrass can also occupy the subtidal zone.

The open water environment around YBI and Treasure Island is almost entirely marine in composition due to a lack of significant freshwater flow (CCSF 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 Piers E4 to E18. Additionally, many bird species are known to forage and nest throughout this area.

<u>2.3.2 Status of Species and Critical Habitat in Action Area</u>

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 Piers E4 to E18 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. Juvenile Chinook salmon were also found infrequently near Piers E4 to E18 between March and August in the Bay Study. Trawl data from the Bay Study recorded 91 individuals captured within the three sites closest to Piers E4 through E18 between 1980 and 2014; however, all of these individuals were caught between February and August.

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. 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 trawl. NMFS does not expect Adult Chinook near Piers E4 to E18 since during the summer and fall months 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, and if they are present within the action area, this is most likely to occur during the winter and spring months.

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 Piers E4 to E18, 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 the Piers. There are no occurrences of steelhead in the Bay Study trawl data from 1980 through 2014 for the sites closest to the Piers. 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.

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 2014.

During the Pier E3 Demonstration Project, a trawling study was conducted before and after the implosion of the pier to collect fish within the modeled 187 dB cSEL and 183 dB cSEL exposure areas of the Pier E3 implosion. This was intended to get an estimate of the species assemblage, composition and relative abundance present in the area during the time of the blast, as well as to discern impairment to those fish exposed to high sound pressure waves (see trawl study results

Caltrans 2016b).

A total of 203 fish, made up of 15 species were collected pre-implosion on October 31, 2015. Trawls captured 151 speckled sanddabs (*Citharichthys stigmaeus*), which were primarily juveniles. The next most abundant species were 14 California halibut (*Paralichthys californicus*), ten plainfin midshipman (*Porichthys*), and nine brown rockfish (*Sebastes auriculatus*). These species also were primarily composed of juvenile-size classes. No Federal or State-threatened or endangered fishes were collected.

On November 14, 2015, a total of 1,229 fish were collected post-implosion. Nine species were collected within 60 minutes following the implosion. The trawling mostly occurred between 2,500 and 4,000 feet from the pier, and began immediately after the implosion was over. Trawls captured 1,073 juvenile anchovies. The next most abundant species captured by the trawls included 92 speckled sanddabs, 21 California halibut, and 17 brown rockfish. All fishes caught were juveniles. No Federal or State-threatened or endangered fishes were collected.

Based on life history patterns, seasonal distribution and migration patterns, and trawl data, NMFS does not expect adult and juvenile CV spring-run and Sacramento winter-run Chinook salmon will be present in the action area during the removal of Piers E4 to E18 with the use of controlled charges. However, they could be transiting through the area in the winter and spring months (December 1st – May 31st) when some pile proofing and debris removal activities occur. Both CV steelhead and CCC steelhead are known to occur near Piers E4 to E18, however due to their typical migration patterns and life history traits, CV steelhead are not expected to be present in the action area during the implosion of Piers E4 to E18, but a small number could 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, PBFs 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 estuarine PBFs 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.

PBFs of designated critical habitat for Sacramento winter-run Chinook salmon in the action area are habitat areas and adequate prey that are uncontaminated. These PBFs 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.

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 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 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, personal communication 2014). Outmigration of adults through the Golden Gate Bridge also appears to be rapid with departure times between December and February. Of more than 200 tagged

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

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 the Piers. 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 Piers E4 to E18 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 2014 (34 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). No sturgeon were captured during the two trawls conducted in the action area pre-and-post-implosion of Pier E3 during the Demonstration Project. Therefore, based on the available data, NMFS believes green sturgeon could be present during the remaining SFOBB activities, including the removal of Piers E4 to E18, but their abundance in the action area is expected to be very low.

4. Green Sturgeon Critical Habitat

The project's entire action area is located within designated critical habitat for the southern DPS of green sturgeon. PBFs for green sturgeon in estuarine areas are: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. These PBFs 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 were 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 20th 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). 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). Dredging, aggregate (sand) mining, and borrow pit mining has permanently removed an estimated 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*. This clam is native to rivers and estuaries of East Asia and was likely introduced into the Bay in the late 1980s by ship ballast water discharge. *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 through the SFOBB Mitigation Fund that may provide habitat enhancements for salmonids and green sturgeon.

2.3.4 Previous Section 7 Consultations in the Action Area

From 2000 through 2016, 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, construction of bridge structures, and the removal of Pier E3 with controlled underwater blasts. 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 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.

[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.

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 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 fishes. 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 Pa^2-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 (no pile driving occurred in 2015). 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 for pile driving activities.

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 (*e.g.*, pile proofing in winter, December through May). 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 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 is 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.

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).

3. Removal of Pier E3 with the use of Controlled Charges

On November 14, 2015, Caltrans removed Pier E3 using controlled charges and imploded the pier into its open hollow cellular caisson below the mudline (*i.e.*, the Bay floor). As required, a BAS was used to minimize potential impacts on biological resources in the Bay. Collected data indicate greater reduction and minimization of environmental impacts associated with compressive sound pressure waves generated during the underwater blasts than originally modeled and proposed by Caltrans (from the expected 2,500 and 4,000 to only 1,000 meters away from the pier). Also, completion of the Pier E3 Demonstration Project supported the finding that use of controlled blasting reduced the extent and duration of adverse effects on environmental resources compared to conventional dismantling methods (*i.e.*, coffer dams, pile driving, and mechanical dismantling) by reducing the in-water work periods for dismantling Pier E3, from approximately four years to a few weeks. In addition, monitoring reports, including bird predation, hydroacoustic sound measurements and trawl data indicate the test and implosion blasts would have minimal impacts on fish and marine mammals. No ESA-listed species were observed as harmed or collected during the controlled test and implosion blasts.

2.3.6 Effects to Listed Species from Otter Trawling

As part of the required CDFW monitoring for the Pier E3 Demonstration Project, Caltrans conducted otter trawls immediately after the implosion of the pier. The area that was trawled covered the area that coincided with the original modeled distance (not the actual measured distances) to reach the 187 cSEL and 183 cSEL radial distances from Pier E3. These distances extended beyond the range of injury for green sturgeon (and salmonids), but was done in an attempt to help CDFW monitor for impacts to longfin smelt and other fish species. No green sturgeon or salmonid species were captured during any of the trawls which indicated species absence as well as the unlikeliness that any green sturgeon were killed or temporarily stunned during the blast and adrift in the Bay currents after blast.

2.3.7 Effects to Water Quality from Pier E3 Demonstration Project

After the demolition of Pier E3, water quality sampling and monitoring reports showed turbidity generated by the Pier E3 implosion peaked at 25 NTU and pH peaked at 9.0 standard units, returning to background levels within a few hours after the implosion. The water quality monitoring and sampling effort included the use of current tracking drogues, dynamic plume mapping, grab sampling, sediment sampling and environmentally sensitive area monitoring.

2.4 Effects of the Action

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

The SFOBB Seismic Safety Project and associated Pier E4 to E18 Removal 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. 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. As mentioned previously, only a very small percentage of fish from the three Central Valley ESUs (CV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon) will likely be present in the SFOBB East Span Piers E4 to E18 Removal Project action area during the associated bridge demolition (primarily pile proofing and debris removal activities) and vulnerable to the adverse effects of high sound pressure levels. For the three listed salmonid ESUs, 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 the Bay study indicates some juvenile Chinook may be present in the area between February and August, the number of juveniles that use this area is likely very small; since it is generally thought that smolts originating from Central Valley streams, also utilize the north side of the Bay as their primary migration corridor (MacFarlane and Norton 2002, Jahn, J. 2004).

2.4.2. Use of Controlled Charges for Removal of Piers E4 to E18

Caltrans, in coordination with CDFW and NMFS, determined that the Bay Study data and Pier E3 Demonstration Project trawl study represents the best available information on fish distribution in the Bay and on fish species composition and population densities in the Sacramento–San Joaquin Bay Estuary, although these data were not specifically collected with the intent to estimate population densities (see Section 2.3).

Since the Pier E3 Demonstration Project involved removal of a single pier, the implosion was planned to occur in November, which was identified by Caltrans and the resource agencies as the preferred time for the implosion of Pier E3 because that was when the listed fish were least likely to be present near the pier. When considering the removal of Piers E4 through E18, a larger implosion window was considered to accommodate the removal of multiple piers per year. When considering removal of multiple piers in a single year, Caltrans has worked to balance several competing temporal constraints (Caltrans 2016a). Because of Caltrans' need to effectively monitor the implosion work, no nighttime implosions will occur. Since Caltrans must also temporarily halt traffic on the SFOBB for safety reasons during the blasts, weekends are the best daylight options to conduct the implosions. Given the limited number of weekends during the fall months Caltrans has expanded the work window to include weekends in September, October, or November, as well as conducting clean-up through December 15 each year. This expanded work window would be needed for Caltrans to successfully implode multiple piers in a year while also completing necessary clean-up work.

Using the Bay study and Pier E3 Demonstration Project's otter trawling data, the best months for implosion of the piers and avoidance of listed species would be September, October, and November. To evaluate changes in impacts on fish species associated with conducting implosions in these months, Caltrans conducted an analysis of the seasonal fluctuations in fish densities in the project area, by species. To evaluate potential impacts from the controlled implosions of Piers E4 to E18, Thiessen polygons, or nearest neighbor polygons, were generated around all Bay Study sample points to define areas associated with each Bay Study site location (Figure 8). Portions of Bay Study sample polygons 110, 211, and 212 are the three transects that occur in the action area. To evaluate the seasonal distribution of fish species in the vicinity of Piers E4 to E18, Caltrans analyzed Bay Study data, collected from 1980 to 2014 for sample polygons 110, 211, and 212, which represent the closest sample points to the project. Monthly population fish densities were averaged for the entire 34-year data set to identify seasonal time frames when the densities of individual species were highest and lowest in the action area. Using these seasonal distributions for each species, the lowest fish density time periods to complete the project were evaluated, which is how the months of September, October and November were determined to be the optimal months to use controlled blast charges (Caltrans 2016a, b).

Data from the Bay Study were also used to calculate September, October, and November monthly densities for managed and listed species, including Chinook salmon, steelhead, green sturgeon, jacksmelt (*Atherinopsis californiensis*), northern anchovy (*Engraulis mordax*), Pacific herring, Pacific sardine (*Sardinops sagax caerulea*), English sole (*Parophrys vetulus*), and longfin smelt. In addition, Caltrans performed 13 trawls on October 31, 2015, before the implosion of Pier E3, 14 trawls on November 14, 2015, immediately after the implosion. These included both mid-water and otter trawls. These October and November trawls were used to supplement the Bay Study data for the purpose of estimating monthly fish densities in the months of October and November, respectively.

Density data for ESA-listed fish species in the action area during September, October, and November were calculated by averaging the catch data for each month, collected in midwater or otter trawls over the most recent five years available (2010 to 2014) corresponding to sample points 110, 211, and 212. The number of fish captured was divided by the volume of water sampled (mid-water trawls) or the area of Bay floor sampled (otter trawls) at each sample point. These densities, expressed either as fish per cubic meter of water or fish per square meter of Bay floor, then were extrapolated across the respective Thiessen polygons to yield an average density per species in each sample point polygon.

In addition, as a comparison against the number of potentially affected individuals in the action area, an estimate of the larger September, October, and November Central/South Bay population was calculated by using this method to apply polygon-specific densities to Sites 101 through 142 for the South Bay and 211 through 244 for the Central Bay.

To estimate the total number of fish potentially affected by each implosion, impact isopleths (*i.e.*, 183 dB cSEL, 187 dB cSEL, and 206 dB peak) were overlaid on the polygons (*i.e.,* 110, 211, and 212). These polygon-specific fish densities, per species, were applied to the volumes (for mid-water trawl species) and areas (for otter trawl species) of overlapping impact isopleths (Caltrans 2016a). Piers E4 through E6 overlap Bay Study polygons 110 and 211, Piers E7 through E12 overlap polygons 110, 211, and 212, and Piers E13 through E18 overlap polygons 110 and 212. Although no green sturgeon were captured during these months in the Bay Study, based on tagging data (see Section 2.3.2.3) and data obtained from bycatch in fisheries along the West Coast, including some trawl fisheries, sub-adult green sturgeon may occupy the Bay, and potentially the area around the old SFOBB bridge including Piers E4 to E18 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. Therefore, NMFS assumes the lack of catch in Bay Study years indicates lower numbers present in the action area during the months of September – November. Since the Bay Study is a sample of fish in the Bay (not a census), 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 a very low number of green sturgeon would be present in the area during each implosion event.

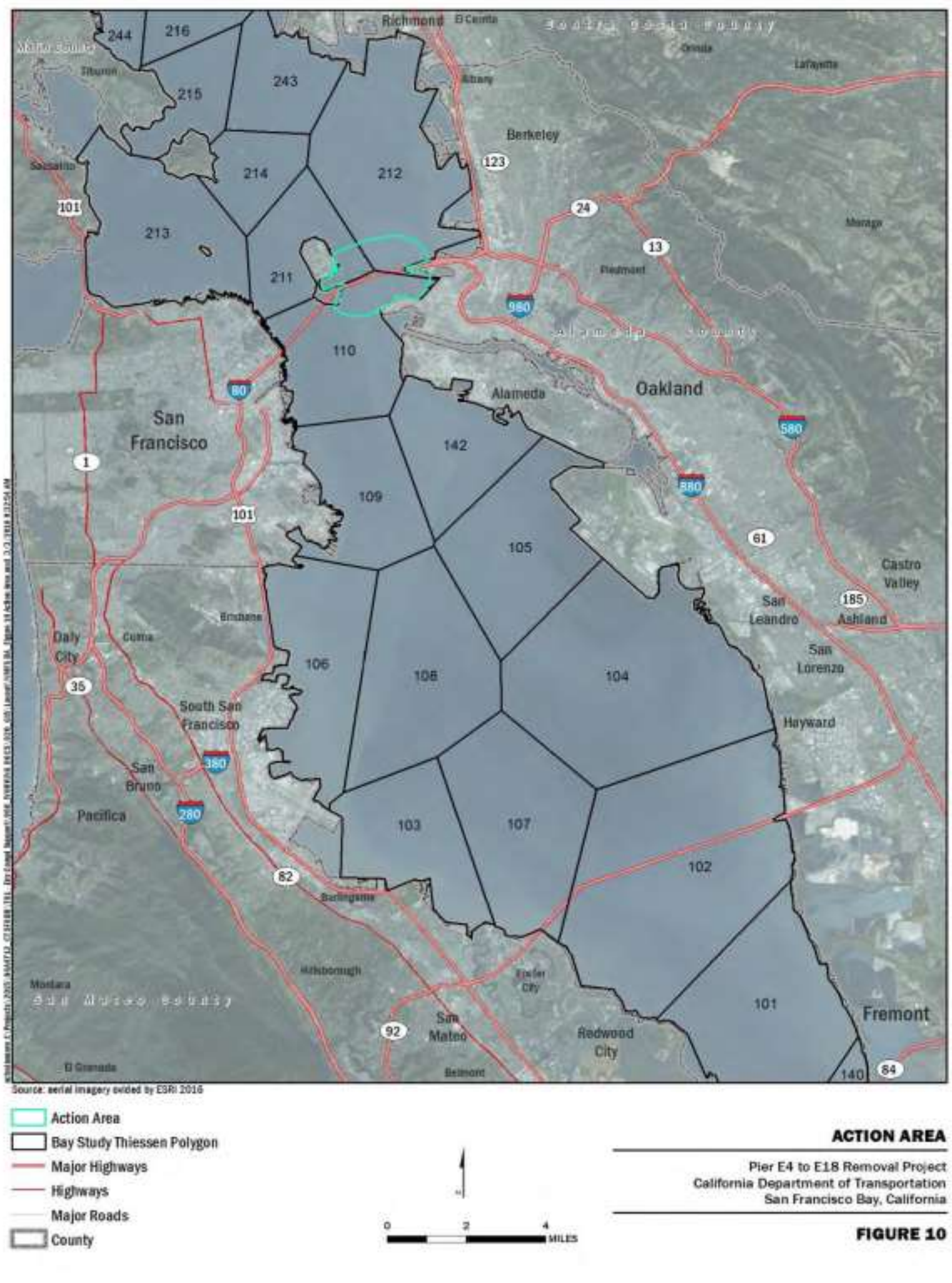


Figure 8. Polygon transects of fish density for the months of September through November

2.4.3 Underwater Sound Pressure and Exposure on Fish

Fish may be injured or killed when exposed to high levels of underwater sound, such as those generated by impulsive sound sources such as pile driving with impact hammers, airguns, and underwater blasts. Pathologies of fishes 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. As the pile is driven into the substrate and meets resistance, a wave of energy travels 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.

Differences in fish sensitivity to acoustic pressure may also be the result of the presence and type of swim bladder, and more importantly, the proximity and linkage of the swim bladder to the ear (Popper *et al.* 2003; Braun and Grande 2008, Halvorsen 2012). Both salmonids and green sturgeon possess swim bladders. Fishes with swim bladders may be more sensitive to sound, and therefore more susceptible to injury from underwater sound exposure, than are fishes that lack swim bladders. 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 are transmitted to, and stimulate, the inner ear.

Studies conducted during underwater rock blasts have documented the swim bladder of fishes 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 gas bubbles, which can lodge in vital organs such as the heart, brain, and kidneys, resulting in mortality.

There are two types of swim bladders, physotomous and physoclistous. Both salmonids and green sturgeon possess physostomous swim bladders, which means they retain a 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". 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 pressure exposure compared to a fish with an inflated swim bladder (positively buoyant). However, given the rapid rise time of impact hammer pile driving and the blast exposure a fish most likely will not be able to regulate air quickly, and since there is no way to know the buoyancy state of the fish during exposure to these sound sources, NMFS will assume the worst case scenario that the swim bladders are positively buoyant, and therefore, exposed fishes 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 fishes 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 fishes 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, 187 dB cSEL at 34 m, and 150 dB RMS at 398 m;
- For proofed piles, 206 dB peak SPL at 7 m, 187 dB cSEL at 19 m, and 150 dB RMS at 3981 m;
- For the steel H-piles, 206 dB peak SPL at 10 m, 187 dB cSEL at 65 m, 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 expected to result in adverse effects to a very few juvenile Chinook. No other ESA-listed salmonids life stages are expected to be present during this time. Additionally, during this time, the project's pile driving activities are not expected to result in impacts to adult spawning green sturgeon. However, juvenile, sub-adult and some nonspawning adult green sturgeon have the potential to be within the action area year-round. 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 fish movement occurs. 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. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juvenile Chinook were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. 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.

During the winter and spring months, pile proofing may occur, which has the potential to affect migrating salmonids (primarily CCC steelhead), 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 (2016-2017), 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 driving. 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 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 (if any) piles for falsework and trestle construction because sections of the old bridge can now be removed and loaded onto barges, rather than onto trucks. No piles were installed during the 2015 work season. 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. However, since Caltrans is not certain what pile driving may need to occur, we will base our assumptions on the worst case scenario that all pile driving will occur with an impact hammer, and therefore a very small number of listed salmonids and green sturgeon may be injured or killed during these events.

Use of Modified "Spud-Pile" to breakdown Pier E5. Caltrans anticipates SPLs generated during the breakdown of concrete for Pier E5 with the use of the modified spud pile will be similar to impact driving of a concrete pile. Specifically, since the demo spud pile is solid, it will not ring like a steel pile. However, it will generate impulsive sounds as the energy is transferred into the concrete structure. Driving of a concrete pile produces sound levels of approximately 195 dB peak, 180 dB RMS and 165 dB SELss at ten meters from the pile. Pier E5 has a total of ten chambers which will need to be broken open with the spud-pile. Caltrans anticipates it will take a maximum of 40 strikes to break open all the chambers (4 strikes/concrete slab). Using this information, NMFS does not anticipate SPL threshold values to be exceeded beyond the following distances surrounding Pier E5 during the breakdown of the concrete slabs for fish greater than or equal to two grams: 206 dB peak SPL at 2, 187 dB cSEL at 6m, and 150 dB RMS at 1000m. This activity will also be restricted to the June 1st to November 30th work window, therefore only a very small amount of juvenile Chinook or green sturgeon may be present and would likely only be exposed to sound levels that would cause harm or illicit some type of temporary behavioral response.

Use of Controlled Charges to Remove Piers E4 to E18. At the time the current impulsive sound thresholds for fish were established, the available information was limited to different types of impulsive sound sources, including underwater explosions and seismic airgun blasts. More recently, the authors of Popper *et al.* (2014) did a thorough review of available data associated with fishes and explosions and concluded "The problem for setting guidelines is that the studies that have examined the effects of explosions on fishes have each used different species, different types of explosives, and/or charges of different weights." Since the methodologies and data are so varied, Popper *et al.* 2014 did not provide any threshold recommendations beyond mortality and mortal injury (based on data from Hubbs and Rechnitzer 1952). In our analyses of impacts on fish from exposure to explosives, NMFS requires a threshold to determine the onset of injury not just mortality. Because of this, NMFS has determined that the current FHWG thresholds for impulsive sounds produced during pile driving are suitable and conservative 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 but take into account onset of physical injury and temporary threshold shifts in hearing. Using this rationale, Caltrans calculated the distances to reach the respective thresholds from Pier E4 to E18 during implosion events. For ESA-listed fish species, this results in a potential impact area where onset of injury to fish could occur within a 106 acre area for each implosion (a total of 394 acres for all implosions), corresponding to the following threshold distances: 206 dB peak at 355 meters (1,165 feet), and 187 dB cSEL at 271 meters (889 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 implosions themselves. 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 6 meters (20 feet) from Piers E4 to E18 during each discrete blast.

No ESA-listed salmonids are expected to be present during the implosions (September – November). Only green sturgeon, two grams or larger 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 E4 to E18 during each implosion event. However, because of the timing of the implosions in September, October or November, site conditions, and duration (one to five seconds) of the blast, green sturgeon are expected to be present 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. In addition, each pier implosion will be sequenced so that only one event occurs within a given day, with at least a 12-hour break in between each event. This will allow a recommended amount of recovery time and plenty of transit time for any fish exposed to the one to five second duration of each blast, which will greatly minimize the potential to accumulate sound exposure from each blast.

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 which may also affect responses. 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. NMFS notes that these studies were done in controlled environments (*e.g.,* confined) and that actual behavior in the wild may be very different.

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 fishes. 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. An even smaller area may be affected from the removal of Pier E5 during the use of the modified spud-pile to break apart the concrete caps. This would encompass a radius of 1,000 meters away from the Pier. 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 implosions of Piers E4 to E18, Caltrans estimates the total area where fish may exhibit a behavioral response to the controlled implosion will encompass an area of approximately 1,477 acres for each blast event (a cumulative total of 2,461 acres over the duration of the project), corresponding to the distance to reach the 150 dB RMS radius of 1,448 meters (4,752 feet) from the Piers during each implosion. An even smaller area is expected to be affected during any test blast based on the data from the test blasts used during the implosion of Pier E3. The estimated distance to reach the 150 dB RMS threshold would be no more than 23 meters (75 feet) from Piers E4 to E18 during any test blast event. 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 one to five seconds, if a fish perceives the sound in that very short timeframe, any startle responses fish exhibit are likely to extinguish quickly, without harm or injury, after the detonation.

<u>2.4.4 Water Quality</u>

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 project would result in minimal impacts to water quality parameters affected by turbidity, pH, contaminants, and dissolved oxygen. For the Pier

E3 Demonstration Project, turbidity increases after the implosion were quickly restored to background conditions in the Bay, within a matter of hours. Because of the similarity of activities and locations between the Pier E3 implosion and the implosion of Piers E4 through E18, the water quality impacts are expected to be similar. Caltrans will ensure to the extent practical that turbidity generated by the project activities do 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. Thus impacts to water quality will be temporary in duration, expected to completely dissipate within a few hours 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.

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 Piers E4 to E18. 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 caissons. During the implosion of Piers E4 and E5, the outer walls of the caissons above and below the mudline will remain intact. Because of this, the caissons will act essentially as a cofferdams and keep the vast majority of debris and sediment trapped, limiting the amount of re-suspended sediment from mixing with the surrounding Bay water. Similarly the open voids of Piers E6 to E18 will capture debris. In addition, the air flux generated by the BAS surrounding all of the piers is expected to help contain any turbidity surrounding all of the piers during the implosions, which will also help to minimize the area affected by resuspended sediments. However, there will be some mixing and some sediment resuspension resulting from the implosions, and concrete and other debris falling outside the caissons and walls of Piers E4 to E18, 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 of Pier E3, 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 effectiveness of the BAS as a minimization measure is supported by the findings from similar marine projects and the Pier E3 Demonstration Project. These estimates and measured data from the Pier E3 Demonstration Project can be used to estimate what is reasonably certain to occur for the implosions of Piers E4 to E18. 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 have negligible ability to resuspend sediment. Therefore, most of the resuspended sediment is expected to be contained within the BAS surrounding each 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. However, measured values after the implosion of Pier E3 indicated the turbidity peaked at 25 NTU and pH peaked at 9.0 standard units, returning to background levels approximately four hours after the implosion. Similar results are expected for the remaining piers. Given the small degree of uncertainty with what may be encountered with the concrete and internal sediment of the remaining piers, there could 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 implosions as well as the air flux generated by the BAS. This did occur with the implosion of Pier E3. 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 the piers, 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 the Piers. However, as with the turbidity plume, this pH spike would be dispersed within a few hours after 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 caissons 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 caissons or removed off-site. As concrete or other debris are removed from the Bay floor surrounding each pier, 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 Piers E4 to E18, 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 salmonids during debris removal and green sturgeon during the implosions and debris removal activities.

ESA-listed salmonids 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 post-implosion debris removal work is not expected to impair or harm listed salmonids. Similarly for 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.

<u>2.4.5. Critical Habitat Effects</u>

Designated critical habitat for CCC steelhead, Sacramento winter-run Chinook and southern DPS North American green sturgeon occurs in the action area. PBFs of critical habitat for salmonids found within the action area include the estuarine water column, benthic foraging habitat, and food resources used by steelhead as part of their juvenile downstream migration and adult upstream migration. For Sacramento winter-run Chinook, PBFs include habitat areas with adequate prey that are uncontaminated. PBFs for green sturgeon in estuarine areas are food resources, water flow, water quality, a migratory corridor, water depth, and sediment quality.[8] Pile driving, underwater detonations for pier removal, 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 PBFs 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 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 Pier E4 to E18 Removal Project's implosion activities, a BAS will be installed around each pier, which will reduce the area of critical habitat affected by noise that exceeds the established thresholds that lead to onset of injury or mortality and can alter fish behavior. Under the assumption of an 80% effective BAS, 1,477 acres (a 1,448 meters [4,752 feet] linear distance around Piers E4 to E18 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 would receive sound levels at or greater than the 206 dB peak and 187 dB cSEL metrics, adversely affecting this area of critical habitat by making it temporarily likely to cause injury or death to listed green sturgeon attempting to use it. This area of critical habitat is approximately 106 acres (a radial distance of 356 meters from the piers). Additional BMPs will be implemented to minimize the potential for hazardous materials or debris to enter critical habitat during pre-implosion construction activities. Because the duration of each implosion is only one to five seconds, and any turbidity generated from the implosion is anticipated to dissipate within four hours post-implosion, the effects on critical habitat PBFs for these species are insignificant.

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[8] See section *2.2.1 Species Description, Life History, and Status* above for a detailed listing of salmonid and green sturgeon PBFs.

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 PBFs of salmonid or green sturgeon habitat because increases in turbidity levels will be minor and temporary, and water quality is expected to improve within a short period following pile driving and removal (within four hours) following the implosion, and quickly after any clam-shell or crane removal of fallen debris.

Foraging Habitat. Pile driving and removal, and removal of concrete or other caisson debris from around each pier after the implosions could disturb and remove a very small amount of the top layer substrate habitat surrounding the piers 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, 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 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 Piers E4 to E18 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 removal of Piers E4 to E18 with controlled charges and associated debris removal activities conducted under the proposed action is not likely to reduce the quality of the PBFs for green sturgeon critical habitat within the action area.

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

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.

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

The remaining pile driving activities associated with the SFOBB East Span Seismic Project (and associated the Piers E4 to E18 Removal) 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 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 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 2012-2018 construction periods analyzed in the 2012 BO. For the remainder of bridge east span removal activities in 2015-2018, 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 2014 (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. 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. Additionally, 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.

Similar to salmonids, (primarily 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 juvenile or subadult 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 significantly 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 Pier E4 to E18 Removal Project, as described below

Since the Project's proposed method for pier removal utilizing underwater explosives will only occur in September - 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 blasts 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 blasts, 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 the blasts or associated sediment disturbances from 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 Piers E4 to E18 would result in the permanent creation of approximately 36,431 cubic meters of open water (pelagic) habitat.

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 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. No green sturgeon adults are expected to be harmed by the project. In addition, 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 Pier E4 to E18 Removal Project.

As described above in the Effects of the Action section (2.4), effects on salmonid and green sturgeon critical habitat are minor and temporary. We have concluded that most of these effects are insignificant because most critical habitat will return to its previous condition within hours after project operations cease. Very small areas of critical habitat may experience reductions in benthic organisms (green sturgeon prey species) that may last for months or a few years. However, these areas are very small relative to similar areas nearby and elsewhere in San Francisco Bay. Food supplies for green sturgeon in and near the action area will remain at levels that support the value of PBFs for green sturgeon in San Francisco Bay.

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 will have ceased prior to the climate change impacts described above being realized.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Central Valley steelhead or Central Valley spring-run Chinook salmon. No critical habitat has been designated or proposed for these species in the action area; therefore, none was analyzed. After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CCC steelhead, Sacramento River winter-run Chinook salmon or southern DPS green sturgeon or destroy or adversely modify their designated critical habitat.

2.8 Incidental Take Statement

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

2.8.1. Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

Pile driving with an impact hammer is expected to result in incidental take in the form of injury, mortality or harassment to salmonids and green sturgeon through exposure to temporary high SPLs (≥ 206 dB peak SPL, 187 dB cSEL and 150 dB RMS) 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 19 m radial distance from the pile during attenuated pile driving of the 36-inch diameter steel piles, within the 7 m radial distance for unattenuated pile proofing of the 36-inch piles, and within the 33 m radial 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 μPa^2-sec), or 150 dB RMS (re: 1 μPa) extend beyond these distances the amount of incidental take may be exceeded.

During the Pier E4 to E18 Removal 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 blasts and controlled implosions of Pier E4 to E18. The number of listed green sturgeon that may be incidentally taken during the Pier E to E18 Removal Project is expected to be very low due to duration of the blast (no more than five seconds) and the time of year (September - November) when the blasts will take place. However, any fish located within a distance of 356 meters (1,165 feet) and 889 meters (271 feet) of each pier (corresponding to the area where sound pressure levels could be equal to or greater than 206 dB peak or 187 dB cSEL, respectively), could be injured or killed during each blast event. No green sturgeon less than two grams are expected to be present therefore only the distance to reach the 206 dB peak and 187 dB cSEL threshold represents the entire area where fish may be injured or killed. Beyond this distance, extending out to the 1,448 meters (4,752 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 μPa^2-sec), or 150 dB RMS (re: 1 μPa) extend beyond these distances the amount of incidental take may be exceeded during the implosions.

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 Central Valley Steelhead, Central Valley Spring Run Chinook Salmon, Central Valley Winter Run Chinook Salmon, Central California Coast Steelhead, the Southern DPS of Green Sturgeon or destruction or adverse modification their critical habitats.

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 salmonids and 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 piers E4 to E18. Ensure blast methods and minimization measures are properly implemented and assist in the evaluation of project effects on listed green sturgeon.

3. Ensure the fisheries and hydroacoustic monitoring plans for the SFOBB Seismic Safety Projects and Pier E4 to E18 Removal Project 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.

1. 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.

2. 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.

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

    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, 187 dB cSEL at 34 m, and 150 dB RMS at 398 m;

        - Proofing of piles, 206 dB peak SPL at 7 m, 187 dB cSEL at 19 m, and 150 dB RMS at 3981 m;

        - Steel H-piles, 206 dB peak SPL at 10 m, 187 dB cSEL at 65 m, and 150 dB RMS at 1311 m.

        - Use of the spud-pile to on Pier E5, 206 dB peak SPL at 2 m, 187 dB cSEL at 6m, and 150 dB RMS at 1000 m;

        - For the BAS attenuated implosions described in this opinion: 206 dB peak at 356 m, and 187 dB cSEL at 271 m, and 150 dB RMS at 1,448 m. For the test charge, the distance for 206 dB peak is 6 m, and for 150 dB RMS, 23 meters.

    b. Caltrans shall submit to NMFS a draft monitoring and reporting program for review and approval 60 days prior to the start of the use of controlled charges 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 each 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
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.
4. Hydroacoustic sound data should be monitored and used to revise subsequent blast plans and sound abatement strategies for additional pier removal as necessary as the project progresses throughout its duration.

2.10 Reinitiation Notice

This concludes formal consultation for the San Francisco-Oakland Bay Bridge Demonstration and Pier E4 to E18 Removal 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. 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, and (3) disturbance of benthic biological community, including removal of prey, and physical habitat.

3.2.1 Underwater Sound Pressure

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 high underwater sound pressure levels generated from pile driving. These high sound levels will temporarily adversely affect EFH. Fish will likely leave the area in response to sound transmitted through water and sediment. Although in some situations, if they are close enough to a pile during the initial strikes, they may be injured or killed.

The use of controlled charges to implode Piers E4 to E18 will create high underwater sound pressures in EFH with potential impacts to fish species managed under the MSA. Fish can be injured or killed when exposed to high underwater sound pressures generated from underwater explosives. These high sound levels will temporarily adversely affect EFH. The duration of the each implosion will last no longer than five seconds, thus fish that are not located within injury zones (within the 183 dB cSEL isopleth) may leave the area in response to sound transmitted through water and sediment. In some situations, if they do not have enough of a response time because of the quick blast timing, 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

When sediment loads remain high for an extended period of time, the primary productivity of an area may be reduced (Cloern 1987). In addition, fishes may suffer reduced feeding ability (Benfield and Minello 1996) and be prone to fish gill injury (Nightingale and Simenstad 2001) if exposed to excessive high levels of turbidity. Fish tend to move out of areas with persistently high levels of suspended sediment. Only short-term, temporary, and localized increases in sediment and turbidity are expected from the proposed installation and pulling of temporary piles. Turbidity would generally be expected to dissipate quickly due to strong currents in the project area. Thus turbidity impacts to fishes are expected to be temporary and minor.

As a result of the underwater implosion, concrete debris and disturbed substrates will create elevated levels in turbidity and suspended sediments. While fishes 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, fishes 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, and debris removal, as well as the sediment and/or other pollutant concentration within the plumes, 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. Although levels may exceed the current water quality objectives for the Bay, the plumes are 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 Piers E4 to E18. However, as with the turbidity plume, this pH spike would be dispersed within a few hours 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. NMFS expects 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 the implosions 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 adjacent to YBI 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). Additional eelgrass surveys were completed in the following three locations before and after the implosion of Pier E3 to analyze effects of the implosion and distance of the turbidity plume. A dense core of eelgrass at Emeryville flats was surrounded by less dense fringes of sparse eelgrass. Comparing this eelgrass bed before and after the implosion activities indicated no detectable silt deposited on eelgrass leaves. At Coast Guard Cove, October and November 2015 surveys mapped eelgrass in these areas. Biologists compared October to November 2015 surveys and detected no change in this eelgrass area, although the side-scan sonar records suggest a slightly extended northward (shoreward) extent of sparse eelgrass leaves in October, compared with November. At Clipper Cove, during the October and November 2015 surveys, eelgrass was not detected in sonar or in direct intertidal and subtidal observations in the survey area (Caltrans 2016a).

All eelgrass beds in the vicinity of the entire SFOBB Project have been designated as environmentally sensitive areas by Caltrans. To protect and demarcate these areas, Caltrans will install and maintain buoys along their outer boundary. To protect eelgrass beds during the Pier E4 to E18 Removal Project, all project-related equipment (barges, cranes, piles, BAS, etc.) will be placed and/or staged outside the eelgrass ESA buoys. 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 project, Caltrans will implement light and turbidity monitoring, consistent with the Bay Light Monitoring Protocol (NMFS 2010).

Removal of debris following the implosions with the use of a clamshell bucket dredge will disturb small areas of benthic habitat surrounding Piers E4 to E18 and within the action area by disturbance and removal of sediment. As discussed in the 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 the piers.

Depending on how many more trestles are needed to be constructed between 2016 and 2018, 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

Because impacts to EFH are expected to minor, temporary and localized (see reasons listed below), there are no practical EFH Conservation Recommendations to provide. 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 Piers E4 to E18 during the implosions will help to contain and dissipate any turbidity generated during the blasts. 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 (one to five 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. Elevated levels of turbidity associated with this project are expected to be minor, temporary and localized.

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

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

5. 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. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the 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[9]). The format and naming adheres to conventional standards for style.

4.2 Integrity

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

[9] Once on the PCTS homepage, use the following PCTS tracking number within the Quick Search column: WCR-2016-5024.

Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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