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

APR - 4 2017

Refer to NMFS No: WCR-2015-1997

Rick M. Bottoms, Ph.D.
Chief, Regulatory Division
U.S. Department of the Army
San Francisco District, Corps of Engineers
1455 Market Street
San Francisco, California 94103-1398

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Chevron Long Wharf Maintenance and Efficiency Project

Dear Dr. Bottoms:

Thank you for your letter of January 20, 2015, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 *et seq.*) for the Chevron Long Wharf Maintenance and Efficiency Project (Project). The Corps of Engineers (Corps) proposes to provide authorization pursuant to Section 10 of the Rivers and Harbors Act of 1899, as amended (33 U.S.C. § 403 *et seq.*) to the Chevron Products Company (Applicant) to complete various upgrades and improvements at the existing Richmond Refinery Long Wharf.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action. NMFS has determined that the proposed Project would adversely affect EFH for various federally managed fish species under the Coastal Pelagic and Pacific Groundfish Fishery Management Plans. However, the anticipated effects are minor, temporary, and localized; thus there are no EFH Conservation Recommendations included in this opinion.

The enclosed biological opinion is based on our review of the description of the work proposed by the Applicant, and describes NMFS's analysis of potential effects on threatened southern distinct population segment (Southern DPS) of North American green sturgeon (*Acipenser medirostris*), threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), endangered Sacramento River winter-run Chinook salmon (*O. tshawytscha*), and designated critical habitat in accordance with section 7 of the ESA.

In the enclosed biological opinion, NMFS concludes the Project is not likely to jeopardize the continued existence of the Southern DPS of North American green sturgeon, nor is the Project likely to result in the destruction or adverse modification of critical habitat for that species. However, NMFS anticipates take of Southern DPS green sturgeon will occur in the form of injury or mortality during the Project's pile driving activities. For threatened CCC steelhead, threatened Central Valley spring-run Chinook salmon, threatened California Central Valley steelhead, endangered Sacramento River winter-run Chinook salmon, and designated critical habitat for winter-run Chinook and CCC steelhead, NMFS has determined the Project is not likely to adversely affect these species in accordance with section 7 of the ESA.

Please contact Ms. Sara Azat of the NMFS North-Central Coast Office in Santa Rosa, California at 707-575-6067, or sara.azat@noaa.gov if you have any questions concerning this section 7 or EFH consultations, or if you require additional information.

Sincerely,

for

Barry A. Thom
Regional Administrator

Enclosure

cc: Naomi Schowalter, Corps Regulatory Branch, San Francisco, CA
Mark Piersante, Chevron Richmond Refinery, Richmond, California
Karen Boven, Chevron Richmond Refinery, Richmond, California
Bill Martin, AECOM, Oakland, California
Admin file #151422WWR2015SR00037
Copy to Chron File

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

Chevron Long Wharf Maintenance and Efficiency Project

NMFS Consultation Number: WCR-2015-1997

Action Agency: Army Corp of Engineers, San Francisco District

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 Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central Valley steelhead (*Oncorhynchus mykiss*)	Threatened	No	N/A	N/A	N/A
Central California Coast steelhead (*Oncorhynchus mykiss*)	Threatened	No	N/A	N/A	N/A
Sacramento Valley Winter-run Chinook (*O. tshawytscha*)	Endangered	No	N/A	N/A	N/A
Central Valley Spring-run Chinook (*O. tshawytscha*)	Threatened	No	N/A	N/A	N/A
North American Green Sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	Yes	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 Groundfish	Yes	No
Pacific Coast Salmon	Yes	No
Coastal Pelagic	Yes	No

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

Issued By: , for

Barry A. Thom
Regional Administrator

Date: APR - 4 2017

TABLE OF CONTENTS

LIST OF ACRONYMS

BOR	Bureau of Reclamation
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
cSEL	cumulative sound exposure level
CSLC	California State Lands Commission
Corps	U.S. Army Corps of Engineers
dB	decibel
DPS	distinct population segment
DWR	Department of Water Resources
DQA	Data Quality Act
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FHWG	Fisheries Hydroacoustic Working Group
FMP	Fishery Management Plan
ft	foot
GCID	Glenn Colusa Irrigation District
Hz	Hertz
ITS	incidental take statement
LTMS	Long term management strategy for disposal of dredged materials in the San Francisco Bay region
µPa	micropascal
mm	millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MOTEMS	Marine Oil Terminal Engineering and Maintenance Standards
NMFS	National Marine Fisheries Service
PBF	physical or biological features
PCE	primary constituent element
RBDD	Red Bluff Diversion Dam
RMS	root-mean-square pressure
SEL	sound exposure level
sq. ft.	square feet
TL	total length

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

1.2 Consultation History

On June 11, 2014, NMFS staff along with representatives of the U.S. Army Corps of Engineers (Corp), California State Fish and Wildlife (CDFW), California State Lands Commission (CSLC), Chevron Products Company (Applicant), and URS (Applicant's consultant, currently known as AECOM) met to discuss the proposed Chevron Long Wharf Maintenance and Efficiency Project (Project).

From June 2014 to October 2014, NMFS, Corps, CDFW, CSLC and the Applicant exchanged various documents clarifying the project description and permit applications. The biological assessment titled, Chevron Richmond Refinery Long Wharf Maintenance and Efficiency Project prepared by URS Corporation, January 2014, was provided to NMFS via email on June 12, 2014, by Chevron.

NMFS submitted questions to the Corp and Chevron via email on the proposed project description and potential mitigation on October 20, 2014. Chevron provided a response to these comments, also via email, on November 13, 2014.

On January 23, 2015, a Corps letter was received by NMFS initiating formal section 7 consultation to address the Project's potential impacts to North American green sturgeon. The Corps also requested NMFS concurrence with their determination that the proposed Project is not likely to adversely affect listed Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, Central California Coast

steelhead. Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Corps made a finding that the Project may adversely affect essential fish habitat (EFH) and requested EFH consultation with NMFS. The Corps provided a copy of the Project's January 2014 biological assessment with their January 20, 2015, letter to NMFS requesting initiation of consultation.

On February 10, 2015, NMFS, the Corp, Chevron and the Applicant's consultant, AECOM, participated in a teleconference to discuss minimization measures and potential mitigation proposals for impacts to habitat.

On July 23, and August 5, 2015, AECOM provided information to NMFS, via email message, regarding potential mitigation sites for the increase in overwater shading proposed by the Project. Information was also provided regarding the project description and project timeline.

On September 22, 2015, NMFS requested clarification from the Applicant and the Corps, via email message, regarding the project description. AECOM responded on September 23, 2015, that a revised project description would be forthcoming.

On December 28, 2015, NMFS requested from the Applicant and the Corps, via email, additional information regarding the action area acreage, number of creosote-treated piles to be removed, project timing, and pile installation schedule. Also, NMFS provided the Applicant and Corps a hydroacoustic monitoring template with that correspondence. There was no immediate response from AECOM.

AECOM provided to NMFS and the Corps the requested information and an updated project description on April 29, 2016. The Applicant submitted a revised permit application to the Corps and the revised application was provided to NMFS by email on May 19, 2016. The Corps permit applications referenced the results of eelgrass surveys; NMFS requested these eelgrass surveys results, and the Corps provided those by email on June 16, 2016.

NMFS and AECOM held a telephone conference on November 17, 2016, to discuss the analysis of hydroacoustic effects associated with pile driving. A summary of the hydroacoustic information discussed and the Project's proposed minimization measures for elevated levels of underwater sound were provided by AECOM to NMFS via email on November 17, 2016.

1.3 Proposed Action

For section 7 of the ESA, "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). For EFH consultation, federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

The Corps proposes to authorize, pursuant to Section 10 of the Rivers and Harbors Act of 1899, as amended (33 U.S.C. § 403 *et seq*.), the Applicant to perform various upgrades and improvements at the Chevron Long Wharf (Long Wharf) adjacent to the Chevron Refinery in Richmond, California to comply with the State of California's Marine Oil Terminal Engineering

and Maintenance Standards (MOTEMS). MOTEMS is a program consisting of periodic maintenance and repair to maintain compliance with the State of California's standards. The Project would consist of modifications to four berths on the Long Wharf in Central San Francisco Bay.

The Long Wharf at Chevron's Richmond Refinery is the largest marine oil terminal in California and its operations are regulated primarily by the CSLC through a State Lands lease, Article 5 of CSLS regulations and MOTEMS. The Long Wharf has existed in its current location, at the eastern terminus of the Richmond-San Rafael Bridge, since the early 1900s. Marine loading arms, gangways and fender systems were installed in 1972, and since then, parts for these loading arms and fender systems have become both difficult to replace and outdated due to changes in the vessel fleet. The purpose of the Long Wharf Project is to improve reliability and efficiency of the facility as well as comply with current MOTEMS requirements.

The Long Wharf is located in Central San Francisco Bay, approximately a half mile south of the Richmond-San Rafael Bridge in Contra Costa County. The project footprint, which includes all construction activities and construction staging, is approximately 5,700 square feet (sq. ft.) (0.13 acre) (Figure 1).

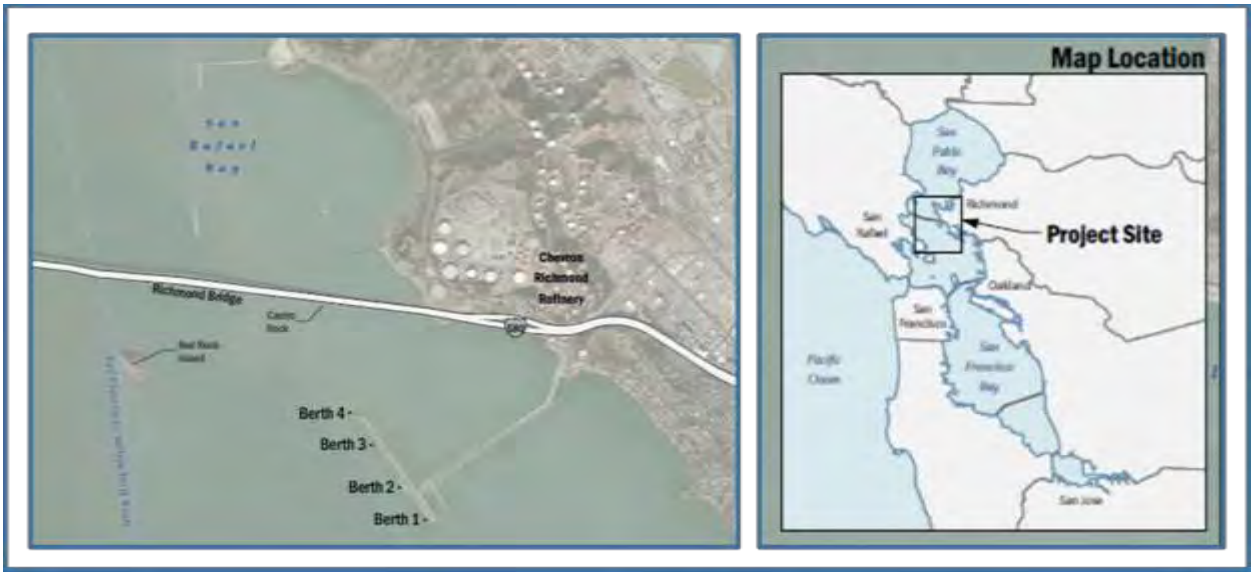

Figure 1. Map and aerial photograph showing the project site and various Chevron facilities in Richmond, California.

Work will occur over a 5-year period from 2018 through 2023, and include replacement of existing wharf infrastructure and addition of some new structural components (mooring and breasting dolphins, internal bracing) along the Long Wharf's four outer berths. Work will be scheduled to enable the facility to remain operational during construction. The general construction sequence is as follows:

- Berth 2 Hose Crane reconstruction
- Berth 4 Seismic work

- Berth 1 Dolphin and Mooring Hook construction
- Berth 2 Fender construction
- Berth 1 Inner Breasting Dolphin construction
- Berth 4 Inner Fender construction
- Berth 1 Gangway tower installation
- Berth 2 Gangway tower installation
- Berth 3 Gangway tower installation
- Berth 4 Breasting Fender Dolphin construction

When complete, the Project will result in a net increase of approximately 4,832 sq. ft. of overwater structure representing less than a one percent increase of the existing wharf structure. The expanded area of overwater coverage is divided between the four berths on the Long Wharf. Thus, the area of 4,832 sq. ft. of new overwater structure is not contiguous. In its entirety, the proposed Project includes the installation of 201 new permanent piles. New permanent piles consist of 14-inch diameter composite piles (total of 52), 24-inch square concrete piles (total of 141), and 60-inch diameter steel piles (total of eight). The Project will also install 36 temporary 14-inch steel H-piles and remove 113 existing timber piles. The new 60-inch and 24-inch diameter permanent piles will be installed with an impact hammer. The new permanent 14-inch composite piles will be installed by vibratory hammer. A vibratory hammer will also be used to install the 36 temporary piles and remove the 113 existing piles (106 timber and 7 concrete). Work at each of the four berths is described below, and presented as new and permanent fill (Table 1), temporary fill (Table 2), and permanent removal of fill (Table 3).

Berth 1.
Work includes gangway replacement and a new raised fire monitor, construction of a new 480 sq. ft. mooring dolphin and hook, construction of a new 692 sq. ft. breasting dolphin (mooring dolphin capable of relieving some of the load from the pier) and a 489 sq. ft. breasting point with standoff fenders (Table 1). The new breasting dolphin will require the removal and replacement of an existing walkway at a new location and the addition of a new walkway. The new walkway will result in a net increase of 38 sq. ft. of overwater coverage. The mooring dolphin and hook, breasting dolphin and gangway will require installation of 42 new 24-inch square concrete piles installed with an impact hammer. The installation of the 24-inch piles and removal of two 18-inch piles would require in-water work activities. All other proposed activities at Berth 1 would occur overwater.

Berth 2.
Work includes gangway replacement and a new raised fire monitor, replacement of one bollard with a new hook, replacement of four timber pile fenders with standoff fenders, and the replacement of existing auxiliary and hose cranes and vapor recovery crane to accommodate the new standoff fenders (Table 1). These activities at Berth 2 will require 51 new 24-inch concrete piles installed using an impact hammer.

In order to keep Berth 2 operational during construction, four temporary fenders will be installed and 36 temporary 14-inch steel H-piles will be driven using vibratory methods to support the fenders (Table 2). These temporary H-piles and fenders will be removed once installation of the permanent standoff fenders is complete. The new fenders will add 368 sq. ft. of overwater

structure; however, removal of the existing whaler will reduce overwater structural area by 509 sq. ft.

Three existing brace piles (22-inch concrete jacketed timber piles) will be removed completely with a vibratory hammer (Table 3). If complete removal is not possible, then the piles will be cut off at least three feet below the mudline.

The installation of 14-inch temporary piles and 24-inch permanent piles and the removal of 106 existing wooden piles at Berth 2 would require in-water work activities. All other proposed activities at Berth 2 would occur overwater.

Berth 3.
Work includes replacement of a gangway and the addition of a new fire monitor. Gangway replacement will require the installation of four 24-inch concrete piles (Table 1). The installation of 24-inch piles would occur in-water, whereas the addition of a new fire monitor at Berth 3 would occur overwater.

Berth 4.
Work includes the installation of two new dolphins, two catwalks, and seismic retrofitting of the Berth 4 loading platform (Table 1). The seismic retrofit will require driving eight 60-inch diameter hollow batter (driven at an angle) steel piles using an impact hammer. To achieve the proper angle for the batter piles, twelve 24-inch steel piles will be temporarily installed, using a vibratory hammer, to support a guide frame template (Table 2). These temporary piles and template will be removed when installation of the 60-inch piles is complete. The loading platform retrofit will add approximately 1,070 sq. ft. of overwater structure. Berth 4 modifications also include the placement of four clusters each of 13 14-inch diameter composite piles (52 total). These composite piles will be installed using a vibrating hammer. These clustered composite piles will serve as permanent markers and protection of the new batter piles on the east side of the retrofit. These clustered composite piles will add 56 sq. ft. of overwater structure (Table 1).

Table 1. New and replacement fill.

Work Component	Overwater Structure Area (sq. ft.)	14-inch taper to 12.25-inch composite	24-inch square concrete (number)	60-inch steel (number)	Piling Area Fill (sq. ft.)	Pile Installation/ Removal Hammer Type
Berth 1						
Mooring Dolphin	480		13		52	Impact
Outer Breasting Dolphin	692		17		68	Impact
Inner Breasting Point	489		8		32	Impact
Gangway	0		4		16	Impact
Walkway	438					Impact
Berth 2						Impact
South Fenders	184		20		80	Impact
North Fenders	184		19		76	Impact
Hose Crane	0		4		16	Impact
Aux. Crane	0		4		16	Impact
Gangway	0		4		16	Impact
Berth 3						Impact
Gangway	0		4		16	Impact
Berth 4						Impact
South Breasting Dolphin & Catwalk	904		22		88	Impact
North Breasting Dolphin & Catwalk	904		22		88	Impact
Loading Platform Retrofit (Total)	1070			8	157	Impact
Barrier Piles (Total – 4 clusters of 13)	56	52			56	Impact
Walkway	340					
Total	**5741**	**52**	**141**	**8**	**777**	

Table 2. Temporary Fill.

Temporary Fill	Overwater Structure Area (sq. ft.)	No. of Piles	Pile Fill Area (sq. ft.)	Pile Installation/Removal Hammer Type
Berth 2 4 Fenders	448			
Berth 2 14 inch Piles to Support Fenders	13	36	13	Vibrate
Berth 4 Loading Platform Template and 24 inch Steel Piles	192	12	38	Vibrate
Total	**653**	**52**	**51**	

Table 3. Permanent Removal of Fill.

Permanent Removal	Overwater Structure Area (sq. ft.)	No. of Piles	Pile Fill Area (sq. ft.)	Pile Installation/Removal Hammer Type
Berth 1 Pile Removal, 18-inch sq. concrete		2	4.5	Vibrate
Berth 1, Existing Walkway Removal	400			
Berth 2 Pile Removal, 106 Wood		106	148	Vibrate
Berth 2 Whaler Removal	509			
Berth 2 Brace piles, 22-inch sq. concrete jacketed timber		3	10	Vibrate/Cut
Berth 4 Concrete Pile Removal		2	8	Vibrate
Total	**909**	**113**	**170.5**	

Installation of Piles with Impact Hammer.
The Applicant estimates each 60-inch diameter steel pile will require 2 hours to install and only one pile would be installed per day. With the installation of eight 60-inch piles, Project construction will include eight days of impact driving of 60-inch steel piles. The eight days for installation of the 60-inch piles will not be consecutive. It will be spread over an eight-week period in a single year during the period between June 1 and November 30. The Project's 24-inch concrete pile will require 1 hour each to install and as many as two concrete piles may be installed per day. The Applicant estimates that installation of concrete piles will occur on approximately 100 days; however, the 100 days will not be consecutive and may occur throughout the 5-year construction period during the work window of June 1 through November 30.

Hydroacoustic Monitoring.
The Applicant proposes to conduct hydroacoustic monitoring at a minimum of two 60-inch steel piles and two 24-inch concrete piles. Piles chosen to be monitored will be representative of mid-channel or typical water depths where piles will be driven. The location of the specific piles to be monitored and the approximate hydrophone locations for each pile being monitored will be determined in the field. At each location, a hydrophone will be positioned at one depth, with a clear line of sight between the pile and the hydrophone at the following distances: 33 feet (10 meters); 65-165 feet (20-50 meters) (depending on water depth at the pile); and between 650-(200 meters) and 1640 feet (1,000 meters) at mid-water column depth measure to estimate the site-specific transmission loss. Airborne measurements will be taken from a position that is 50 to 100 feet (15 to 30 meters) from each pile at a height of 5 to 10 feet (1.5 to 3 meters) above ground, or above the Long Wharf.

Avoidance, Minimization and Mitigation Measures.
The Applicant has proposed the following avoidance, minimization, and mitigation measures:

- All pile driving will occur between June 1 and November 30.
- A bubble curtain will be used when installing the eight 60-inch steel piles.
- To mitigate the new fill and shading and temporary sound impacts, the Applicant has proposed the purchase of mitigation credits at Liberty Island Conservation Bank. In addition, Chevron will contribute funds to the State Coastal Conservancy for removal of 4,971 sq. ft. of piles and overwater structure at Terminal Four in Richmond, California.

"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). NMFS has not identified any interrelated or interdependent actions associated with the proposed action.

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 reasonably certain to occur, 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 (RPMs) and terms and conditions to minimize such impacts.

The Corps determined the proposed action may affect and is likely to adversely affect North American green sturgeon and their critical habitat. The Corps also determined that the proposed action is not likely to adversely affect threatened Central Valley spring-run Chinook salmon, Central California Coast steelhead, Central Valley Steelhead, endangered Sacramento winter-run Chinook salmon or their critical habitats. Our concurrence with the Corps' determination related to ESA-listed salmonids and their designated critical habitat is documented in the "Not Likely to Adversely Affect" Determinations section 2.12 of this opinion. This opinion discusses the potential adverse effects to North American green sturgeon. The effects of the Project on listed anadromous salmonids are presented in section 2.12 below.

2.1 Analytical Approach

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

species.

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

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

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

- Identify the rangewide status of the species and critical habitat 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 by: (1) reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.1.1 Use of Best Available Scientific and Commercial Information

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

- Biological Assessment, Chevron Richmond Refinery Long Wharf Maintenance and Efficiency Project, Prepared by URS Corporation for the United States Army Corps of

Engineers and Chevron Richmond Refinery – Capital Projects. January 2014.

- Mitigated Negative Declaration, Chevron Long Wharf Maintenance and Efficiency Project. California Environmental Quality Act Lead Agency: California State Lands Commission; Applicant: Chevron Product Company. Recirculated October 2016.

Information was also provided in email messages and telephone conversations between June 2014 and November 2016. For information that has been taken directly from published, citable documents, those citations have been reference in the text and listed at the end of this document. A complete administrative record of this consultation is on file at the NMFS North-Central Coast Office in Santa Rosa, California (Administrative Record Number 151422WCR2015SR00037).

2.2 Rangewide Status of the Species and Critical Habitat

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

2.2.1 Species Description, Life History and Status

This biological opinion analyzes the effects of the proposed Chevron Long Wharf Maintenance and Efficiency Project on the Southern DPS of green sturgeon and their designated critical habitat.

2.2.1.1. Green Sturgeon General Life History

Green sturgeon is an anadromous, long-lived, and bottom-oriented fish species in the family Acipenseridae. Sturgeon have skeletons composed mostly of cartilage and lack scales, instead possessing five rows of characteristic bony plates on their body called "scutes." On the underside of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Large adults may exceed 6 feet (2 meters) in length and 100 kilograms in weight (Moyle 1976). Based on genetic analyses and spawning site fidelity, NMFS determined that North American green sturgeon are comprised of at least two DPSs: a northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River ("northern DPS green sturgeon"), with spawning confirmed in the Klamath and Rogue river systems; and a Southern DPS consisting of populations originating from coastal watersheds south of the Eel River ("Southern DPS green sturgeon"), with spawning confirmed in the Sacramento River system (Adams *et al*. 2002).

Green sturgeon are 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 650 foot depth, but spend most of their time in waters between 65-260 feet (20–80 meters) and temperatures of 9.5–16.0°C (Huff *et al*. 2011, Nelson *et al*. 2010). Subadult and adult green sturgeon move between coastal waters and estuaries, but relatively little is known about how green sturgeon use these habitats (Lindley *et al*. 2011). Lindley *et al*. (2011) report multiple rivers and estuaries are visited by aggregations of green sturgeon in summer months, and larger estuaries (*e.g.*, San Francisco Bay) appear to be particularly important habitat. During the winter months, green sturgeon generally reside in the coastal ocean. Areas north of Vancouver Island are favored overwintering areas, with Queen Charlotte Sound and Hecate Strait likely destinations based on detections of acoustically-tagged green sturgeon (Lindley *et al*. 2008, Nelson *et al*. 2010).

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

Adult Southern DPS green sturgeon spawn in the Sacramento River watershed during the spring and early summer months (Moyle *et al*. 1995). Eggs are laid in turbulent areas on the river bottom and settle into the interstitial spaces between cobble and gravel (Adams *et al*. 2007). Like salmonids, green sturgeon require cool water temperatures for egg and larval development, with optimal temperatures ranging from 11 to 17˚C (Van Eenennaam *et al*. 2006). Eggs hatch after 6–8 days, and larval feeding begins 10–15 days post-hatch. Metamorphosis of larvae into juveniles typically occurs after a minimum of 45 days (post-hatch) when fish have reached 2-inches (60–80 millimeters (mm)) total length (TL). After hatching larvae migrate downstream and metamorphose into juveniles. Juveniles spend their first few years in the Sacramento-San Joaquin Delta (Delta) and San Francisco Estuary before entering the marine environment as subadults. Juvenile green sturgeon salvaged at the State and Federal water export facilities in the southern Delta are generally between 200 mm and 400 mm TL (Adams *et al*. 2002) which suggests Southern DPS green sturgeon spend several months to a year rearing in freshwater before entering the Delta and San Francisco Estuary. Laboratory studies conducted by Allen and Cech (2007) indicated juveniles approximately 6-month old were tolerant of saltwater, but approximately 1.5-year old green sturgeon appeared more capable of successful osmoregulation in salt water.

Subadult green sturgeon spend several years at sea before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto *et al*. 1995). Little data are available regarding the size and age-at-maturity for the Southern DPS green sturgeon, but it is likely similar to that of the northern DPS. Male and female green sturgeon differ in age-at-maturity. Males can mature as young as 14 years and female green sturgeon mature as early as age 16 (Van Eenennaam *et al*. 2006). Adult green sturgeon are believed to spawn every two to five years. Recent telemetry studies by Heublein *et al*. (2009) indicate adults typically enter San

Francisco Bay from the ocean and begin their upstream spawning migration between late February and early May. These adults on their way to spawning areas in the upper Sacramento River typically migrate rapidly through the estuary toward their upstream spawning sites. Preliminary results from tagged adult sturgeon suggest travel time from the Golden Gate to Rio Vista in the Delta is generally 1-2 weeks. Post-spawning, Heublein *et al*. (2009) reported tagged Southern DPS green sturgeon displayed two outmigration strategies; outmigration from Sacramento River prior to September 1 and outmigration during the onset of fall/winter stream flow increases. The transit time for post-spawning adults through the San Francisco Estuary appears to be very similar to their upstream migration (*i.e.*, 1-2 weeks).

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

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

2.2.1.2 Status of Southern DPS Green Sturgeon and Critical Habitat

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

CDFW's white sturgeon monitoring program incidentally captures Southern DPS green

sturgeon. Trammel nets are used to capture white sturgeon and CDFW (CDFG 2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the size of subadult and adult sturgeon population. By comparing ratios of white sturgeon to green sturgeon captures, estimates of Southern DPS green sturgeon abundance can be calculated. Estimated abundance of green sturgeon between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and 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 RBDD and the Glenn-Colusa Irrigation District (GCID). Incidental capture of larval and juvenile green sturgeon at the RBDD and GCID have ranged between 0 and 2,068 green sturgeon per year (Adams *et al*. 2002). Genetic data collected from these larval green sturgeon suggest that the number of adult green sturgeon spawning in the upper Sacramento River remained roughly constant between 2002 and 2006 in river reaches above Red Bluff (Israel and May 2010). In 2011, rotary screw traps operating in the Upper Sacramento River at RBDD captured 3,700 larval green sturgeon which represents the highest catch on record in 16 years of sampling (Poytress *et al*. 2011).

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

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

The NMFS status review completed in 2005 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). The most recent status

review was completed by NMFS in 2015. This review concluded the DPS remains likely to become endangered in the foreseeable future and NMFS affirmed no change to the determination that the Southern DPS of green sturgeon is a threatened species (NMFS 2015).

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 PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the Southern DPS of green sturgeon evolved. In addition, the alterations to the Sacramento-San Joaquin River Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to their protracted rearing time in brackish and estuarine waters.

2.2.2 Additional Threats to the Southern DPS of Green Sturgeon

NMFS cites many reasons (primarily anthropogenic) for the decline of Southern DPS of green sturgeon (Adams *et al*. 2002, NMFS 2005). The foremost reason for the decline is the degradation and/or destruction of freshwater and estuarine habitat. Additional factors contributing to the decline of this population include: commercial and recreational harvest, natural stochastic events, marine mammal predation, reduced marine-derived nutrient transport, ocean conditions, and global climate change.

2.2.2.1 Habitat Degradation and Destruction

The best scientific information presently available demonstrates a multitude of factors, past and present, have contributed to the decline of 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 (Adams *et al*. 2002).

2.2.2.2 Commercial and Recreational Harvest

Until recently, commercial and recreational harvest of Southern DPS green sturgeon was allowed under State and Federal law. Since 2006, the threat posed by commercial and recreational fishing has decreased given that intentional lethal take of green sturgeon has been prohibited through fishing regulations (NMFS 2015). Regulations in California, Oregon and Washington prohibit retention of green sturgeon and these regulations pertain to the range of both Southern

and northern DPS green sturgeon. Lethal take still occurs as a result of by-catch mortality associated with the California halibut bottom trawl fishery and incidental catch of green sturgeon occurs in the west coast Pacific Groundfish fisheries. The impact of by-catch in these fisheries on the overall population abundance of the Southern DPS is still unknown (NMFS 2015).

2.2.2.3 Natural Stochastic Events

Natural events such as droughts, landslides, floods, and other catastrophes have adversely affected 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 sturgeon to rebound from natural stochastic events and depressed populations to critically low levels.

2.2.2.4 Global Climate Change

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

The threat to listed 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).

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). Climate simulation models 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).

Estuaries may also experience changes detrimental to green sturgeon. 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). In marine environments, ecosystems and habitats important to 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, Smith *et al.* 2007, Santer *et al.* 2011).

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for the Chevron Long Wharf Project is approximately 3,077 acres and includes the project footprint and all areas below mean higher high water that may be directly or indirectly affected by the Project (Figure 2), including the maximum area that could be affected by elevated underwater sound levels during pile driving.

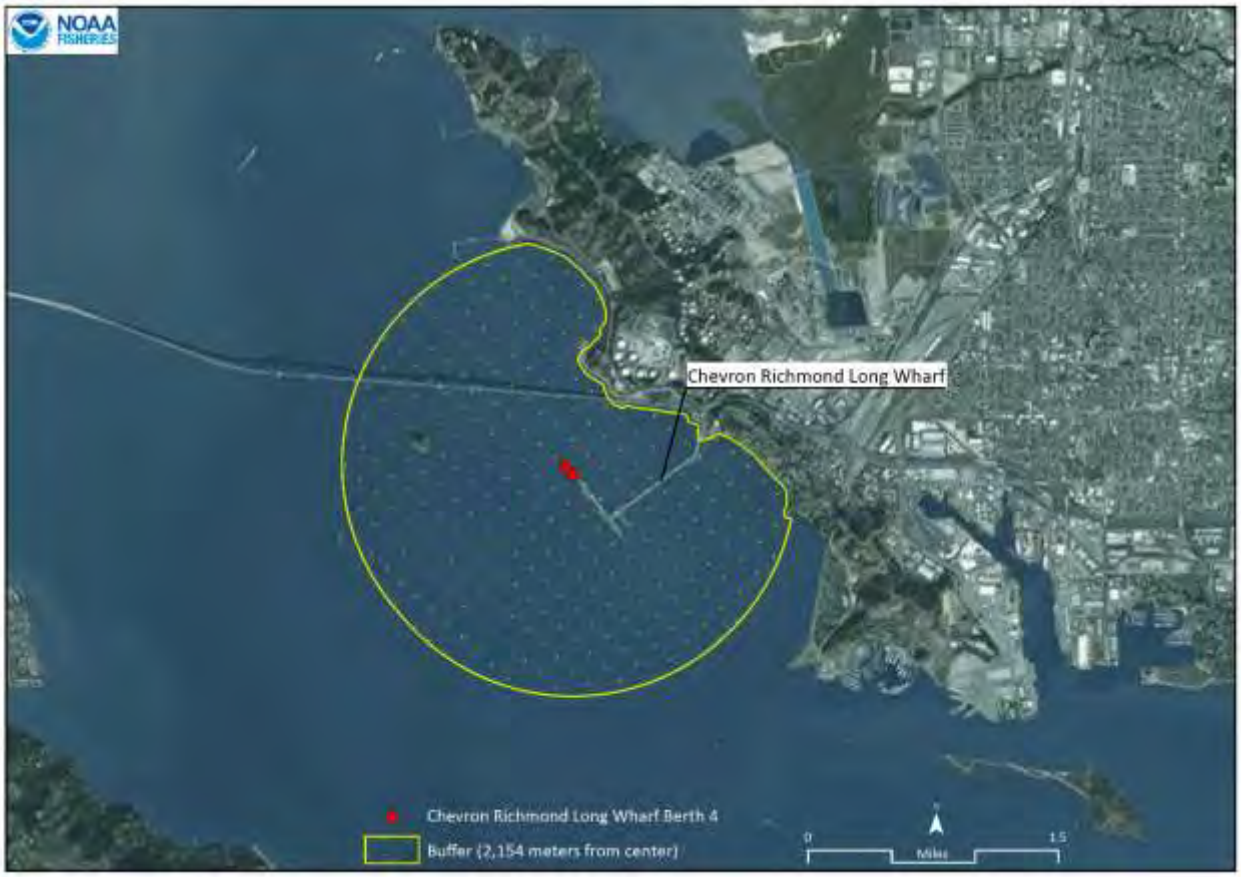

Figure 2. Action Area for Chevron Long Wharf Project. The yellow line depicts the extent of the action area which is the outer edge of 3,077-acre behavioral impact zone from elevated underwater sound during pile driving.

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section

7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The Long Wharf extends offshore from the northeastern shoreline of Central San Francisco Bay at a location approximately ½ mile south of the Richmond-San Rafael Bridge and one mile west of Point Richmond. The shoreline in this area consists of mixed use industrial, housing and a regional public park. Current and wave patterns in the action area are dependent on tides interacting with bottom and shoreline configuration, and this area reflects a strong marine influence in salinity and local biota (Thompson *et al.* 2007, Goals Project 2015). Stormwater runoff and wastewater from municipal and industrial sources vary depending on the location and seasonal weather patterns. Subtidal habitat in surrounding the action area consists of soft bottom (*e.g.*, mud); eelgrass is not present within the action area but is found along the adjacent shoreline. The benthic community is comprised of a number of invertebrates associated with soft bottom habitat, including bivalves, polychaetes, and amphipods (Thompson *et al.* 2007).

2.4.1 Status of the Species and Critical Habitat in the Action Area

2.4.1.1 Green Sturgeon

Adult green sturgeon pass through the San Francisco Bay estuary during spawning and post-spawning migrations. Pre-spawn green sturgeon enter the Bay between late February and early May, as they migrate to spawning grounds in the upper Sacramento River (Heublein *et al*. 2009). Spawning in the Sacramento River occurs during the spring and early summer months and post-spawned adults travel to the bay prior to immigrating to the ocean. Juvenile green sturgeon move into the Delta and San Francisco Estuary early in their juvenile life history, where they may remain for 2-3 years before migrating to the ocean (Allen and Cech 2007, Kelly *et al*. 2007). With juvenile, sub-adult and non-spawning adult green sturgeon utilizing both ocean and estuarine environments for rearing and foraging, these life stages of green sturgeon may be present in the Project's action area throughout the year.

While surveys for green sturgeon have not been conducted in the action area, mud flats and tidal sloughs in Central San Francisco Bay may be used as foraging habitat by green sturgeon. Within the San Francisco Estuary, green sturgeon likely prey on demersal fish (*e.g.*, sand lance (*Ammodytes hexapterus*)) and benthic invertebrates similar to those that green sturgeon are known to prey upon in estuaries of Washington and Oregon (Dumbauld *et al*. 2008). Green sturgeon are also known to be generalist feeders and may feed opportunistically on a variety of benthic species encountered. For example, the invasive overbite clam (*Corbula amurensis*) has become a common food of white sturgeon and green sturgeon in San Francisco Bay (CDFG 2002). Based on distribution data and foraging habits of green sturgeon, NMFS assumes they are present in the action area and likely foraging on benthic prey and fish commonly found in soft-bottom habitats (*e.g.*, ghost shrimp (*Neotrypaea californiensis*), crab, and crangonid shrimp (*Crangon* spp.)) of the San Francisco Estuary. Although soft-bottom habitat exists in the action area, the area is periodically disturbed by dredging for vessel berthing at the Long Wharf, which likely has reduced the quality and quantity of benthic prey organisms available for green sturgeon foraging.

2.4.1.2 Green Sturgeon Critical Habitat

The action area for the Project 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 action area are degraded. Habitat degradation in the action area is primarily due to shoreline and subtidal development, shoreline stabilization, non-native invasive species, discharge and accumulation of contaminants, loss of tidal wetlands, and periodic dredging for navigation.

2.4.2 Factors Affecting the Species Environment in the Action Area

The San Francisco Bay/Delta is one of the most human-altered estuaries in the world (Knowles and Cayan 2004). Major drivers of change in the action area 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).

Land, shoreline, and subtidal areas in the action area have been highly modified by maritime development and the Richmond Refinery. The Long Wharf has existed at its current location near the eastern terminus of the Richmond-San Rafael Bridge since the early 1900s. The current wharf structure was built in 1947 for use by the Richmond Refinery and it was equipped in 1972 with marine loading arms, fender systems and gangways. The Long Wharf is currently the largest marine oil terminal in California. It receives and ships petroleum, oil, byproduct and other petro-chemical products. Between 2008 and 2010, volume transfers averaged 145 million barrels per year, and vessel calls averaged 720 per year. The area is impacted by vessel traffic, and the subtidal area surrounding the Long Wharf is periodically dredged to provide large vessels access to the berths.

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

Pursuant to section 7 of the ESA, NMFS has conducted six interagency consultations in action area related to wharf maintenance activities and dredging at the Long Wharf. NMFS and the Corps completed all six consultations informally based on a determination that the actions were not likely to adversely affect listed salmonids or green sturgeon or their critical habitat. The following is a brief summary of the six previous interagency consultation in the action area:

- Chevron Richmond Long Wharf 2005. (SWR-2004-1689) Replacement of 38 piles.
- Richmond Long Wharf Gangway 2008. (SWR-2008-4713) Installation of an elevated gangway and installation of four concrete piles.
- Chevron Richmond Long Wharf Fender Pile and Berth B Panels Replacement 2013. (SWR-2013-9794) Replacement of 146 timber piles with composite piles, and installation of four steel fender piles.
- Chevron Long Wharf Berth 1 and 5 Fender Piles Replacement Project. (WCR-2014-

1224) Replacement of 26 timber piles and one concrete pile.

- Chevron Long Wharf Maintenance Project, 2015. (WCR-2015-3749) Replacement of up to 50 timber piles with composite fender piles and untreated wood piles.
- Chevron Long Wharf Pile Replacement Regional General Permit, 2016. (WCR-2016-5456) Five-year permit to replace existing timber and concrete piles on a one-to-one basis.

In addition to the projects listed above, periodic maintenance dredging is performed at the Long Wharf. The last maintenance dredging event occurred in 2016. For maintenance dredging at this facility and other locations in the greater San Francisco Bay, NMFS has completed a programmatic consultation with the Corps on the Long Term Management Strategy for Disposal of Dredged Materials in the San Francisco Bay Region (LTMS). The LTMS programmatic consultation resulted in the issuance of a biological opinion on July 9, 2015, to the Corps and the U.S. Environmental Protection Agency. The July 9, 2015, biological opinion concluded the LTMS program was not likely to jeopardize the continued existence of listed fish species under the jurisdiction of NMFS, or adversely modify or destroy designated critical habitat.

Research and enhancement projects resulting from NMFS' Section 10(a)(1)(A) research and enhancement permits and section 4(d) limits or exceptions could potentially occur in the action area. Sturgeon monitoring approved under these programs includes juvenile and adult net surveys and tagging studies. In general, these activities are closely monitored and require measures to minimize take during the research activities. As of March 2017, no research or enhancement activities requiring Section 10(a)(1)(A) research and enhancement permits or section 4(d) limits have occurred in the action area.

2.4.4 Climate Change Impacts in the Action Area

Information discussed above in the species status section of this opinion indicates that green sturgeon in the action area may have already experienced some detrimental impacts from climate change. These detrimental impacts across the action area are likely to be minor because natural and local climate factors continue to drive most of the climatic conditions green sturgeon experience. These natural factors are likely less influential on fish abundance and distribution than anthropogenic impacts across the action area. However, in the future impacts in the action area from climate change are likely to increase as air and water temperatures warm, and precipitation rates change.

2.5 Effects of the Action

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

In this biological opinion, our approach to determine the direct and indirect effects of the proposed action, and interrelated or interdependent activities, on Southern DPS green sturgeon

was based on knowledge and review of the ecological literature and other relevant materials. We used this information to gauge the effects of the proposed project via an exposure and response framework that focuses on what stressors (physical, chemical, or biotic) directly or indirectly caused by the proposed action to which green sturgeon are likely to be exposed. Next, we evaluated the likely response of green sturgeon to these stressors in terms of changes to survival, growth, and reproduction, and changes to the ability of PBFs or physical and biological features to support the value of critical habitat in the action area. Where data to quantitatively determine the effects of the proposed action on sturgeon and their critical habitat were limited or not available, our assessment of effects focused mostly on qualitative identification of likely stressors and responses.

In-water Project activities will occur over a five-year period and Southern DPS green sturgeon are anticipated to be in the action area during all times of the construction of the Project. Elevated underwater sound levels from pile removal and installation and degradation of water quality are expected to occur during construction. Pile removal and installation activities would be limited to the period between June 1 and November 30. Since pile driving is the only in-water construction activity associated with the Project, the effects of construction will be limited to periods of pile driving within 6 months of the year. Permanent effects to critical habitat are expected from the increased amount of overwater structure and new pile installations (approximately 0.12 acres total). The potential effects of the action are presented in detail below.

2.5.1 Effects of Construction Activities on Listed Species and Critical Habitat.

2.5.1.1 Overview of Pile Driving Impacts

Green sturgeon may be affected during construction activities through exposure to high underwater sound pressure levels (SPLs) produced by pile driving with an impact hammer. Fish may be injured or killed when exposed to impulsive sound sources such as pile driving with impact hammers. Pathologies of fish associated with very high sound level exposure and drastic changes in pressure are collectively known as *barotraumas.* These 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. Fish can also die when exposed to lower, continuous sound pressure levels if exposed for longer periods of time. Hastings (1995) found death rates of 50 percent and 56 percent for gouramis (*Trichogaster sp.*) when exposed for two hours or less to continuous sound at 192 decibels (dB) root-mean-square pressure (RMS) (re: 1micropascal [μPa]) at 400 Hertz (Hz) and 198 dB (re: 1μPa) at 150 Hz, respectively, and 25 percent for goldfish (*Carassius auratus*) when exposed to sounds of 204 dB (re: 1μPa) at 250.[1] Hastings (1995) also reported that acoustic "stunning" a potentially lethal effect resulting in a physiological shutdown of body functions, immobilized gourami within eight to thirty minutes of exposure to these sound levels.

Hearing loss in fishes can occur from exposure to high intensity sounds, which can over-stimulate the auditory system of fishes and may result in temporary threshold shifts. A temporary threshold shift is considered a non-injurious temporary reduction in hearing

[1] Pressures will not be added to each metric for the remainder of the section: dB peak has a pressure of 1 μPa, dB sound exposure level (SEL) has a pressure of 1 μPa^2 sec, and a root-mean-square (RMS) dB has a pressure of 1 μPa.

sensitivity. Physical injury may also occur for fish exposed to high levels or continuous sound, manifested as a loss of hair cells, located on the epithelium of the inner ear (Hastings and Popper 2005). These hair cells are capable of sustaining injury or damage that may result in a temporary decrease in hearing sensitivity. However, this type of noise-induced hearing loss in fishes is generally considered recoverable, as fish possess the ability to regenerate damaged hair cells (Lombarte *et al.* 1993, Smith *et al.* 2006). Permanent hearing loss has not been documented in fish. Even if threshold shifts in hearing do not occur, loud sounds can mask the ability of fish to hear their environment. This effect from loud sound exposure is referred to as acoustic or auditory masking. Masking generally results from an unwanted or unimportant sound impeding a fish's ability to hear sounds of interest.

Underwater sound exposures 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. Exposure to pile driving sound pressure levels may also result in "agitation" of fishes indicated by a change in swimming behavior detected by Shin (1995) or "alarm" detected by Fewtrell (2003). 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 produced during pile driving. A fish that exhibits a startle response to a sudden loud sound 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.

In order to assess the potential effects to fish exposed to pile driving sound, a coalition of federal and state resource and transportation agencies along the West Coast, the Fisheries Hydroacoustic Working Group (FHWG), used data from a variety of sound sources and species to establish interim acoustic criteria for the onset of injury to fishes from impact pile driving exposure (FHWG 2008). Most historical research has used peak pressure to evaluate the effects on fishes from underwater sound. Current research, however, suggests that sound exposure level (SEL), a measure of the total sound energy expressed as the time-integrated, sound pressure squared, is also a relevant metric for evaluating the effects of sound on fishes. An advantage of the SEL metric is that the acoustic energy can be accumulated across multiple events and expressed as the cumulative SEL (cSEL). Therefore a dual metric criteria was established by the FHWG and includes a threshold for peak pressure (206 dB) and cSEL (187 dB for fishes 2 grams or larger and 183 dB for fishes smaller than 2 grams). Injury would be expected if either threshold is exceeded. There is uncertainty as to the behavioral response of fish to underwater sound produced when driving piles in or near water. Until new information indicates otherwise, NMFS believes a 150 dB RMS threshold for behavioral responses for green sturgeon is appropriate.

Currently, there are few data available regarding effects of pile driving directly focused on green sturgeon. There is some evidence of pile driving-related underwater sound pressures resulting in mortality of sturgeon during the construction of the Benicia-Martinez Bridge. In 2002, unattenuated piles driven with a large impact hammer at the Benicia-Martinez Bridge Project resulted in the mortality of a 24" white sturgeon (*Acipenser transmontanus*). The piles for the bridge piers were 98-inch (2.5-meter) diameter steel piles and were driven in water about 40 and

50 feet deep in the main channel. Peak underwater sound pressure levels ranged from 227 dB at approximately 16 feet from the pile to 178 dB at approximately 3600 feet from the pile (Buehler *et al.* 2015).

2.5.1.2 Project Specific Considerations.

Several site-specific conditions should be considered when conducting an assessment of the potential effects of pile driving associated with construction projects. Effects on an individual fish during pile driving are dependent on variables such as environmental conditions at the project site, specific construction techniques, and the construction schedule. As presented above, a dual metric criteria of 206 dB peak SPL for any single strike and a cSEL of 187 dB are currently used by NMFS as thresholds to correlate physical injury to fish greater than 2 grams in size from underwater sound produced during the installation of piles with impact hammers. All green sturgeon that may be present within the action area of this project during the June 1 through November 30 pile driving window are greater than 2 grams in size.

Different types of piles (*e.g.*, wood, steel, concrete) result in different levels of underwater sound when struck with a pile driver. For the proposed project, steel, concrete, and composite piles will be used for construction, all of which have different sound signatures. In the updated Compendium of Pile Driving Sound Data (Buehler *et al.* 2015), the most recent pile driving monitoring results are compiled in order to provide information regarding the potential levels of underwater sound pressure levels generated with the installation of different pile and hammer types. Several pile driving case studies conducted within the San Francisco Bay region using steel, concrete, and composite piles are included in the compendium. Impact hammers produce the highest elevated underwater sound levels, particularly when used in combination with steel piles. Vibratory hammers produce less sound than impact hammers and are often employed as a measure to reduce the sound generated by pile driving, and in turn, the potential for adverse effects on fish (Buehler *et al.* 2015).

Water depth at the pile driving site will also influence the rate of sound attenuation. In deep water areas high sound pressure waves are likely to travel further out into San Francisco Bay. Within shallow water, the rate of attenuation is expected to be much higher, reducing the area of adverse effects as compared to deeper water. Pile driving for the proposed project will occur in water depths ranging from approximately 20-40 feet, depending on the specific location on the wharf and tidal phase. Additionally, as distance from the pile increases, sound attenuation reduces sound pressure levels and the potential harmful effects to fish also decreases.

For the Long Wharf Project, the Applicant proposes to use a bubble curtain to attenuate underwater sound levels during installation of the steel piles. Based on the use of a bubble curtain and pile sizes proposed for this Project, the assessment of acoustic impacts presented in this biological opinion assumes an estimated reduction of 10 dB in sound pressure. Although reductions as high as 20 dB have been measured, as a general rule, sound reductions of greater than 10 dB with attenuation systems cannot be reliably predicted (ICF Jones and Stokes and Illingworth and Rodkin, Inc. 2009).

The timing and duration in which pile driving will occur will also greatly influence the level of potential impact on green sturgeon. Pile driving activities for the proposed Project are expected to occur during daylight hours between June 1 and November 30 from 2018 to October 2023. Per day pile driving with an impact hammer is expected to occur for 2 hours or less. The 60-inch steel piles will take eight days of pile driving to install (no more than 1 each day), and the 141 24-inch square concrete piles will require no more than 100 days (1-2 piles per day) of installation with an impact hammer.

2.5.1.3 Assessment of Pile Driving Effects at Chevron Long Wharf

For the purposes of this analysis we have used the maximum distances peak SPLs and accumulated SELs could travel as a reasonable worst case scenario. The highest sound levels associated with construction of the Project will occur during the driving of the 60-inch steel pipe piles with an impact hammer (Table 4). The second highest sound levels generated by the Project are anticipated to occur during the installation of the 24-inch concrete piles by impact hammer. Installation of new permanent 14-inch composite piles will be performed by vibratory hammer. Vibratory hammers will also be used for the installation of the temporary 24-inch steel piles and temporary 14-inch steel H-piles.

Table 4 presents estimates of sound levels associated with impact hammer pile driving. These estimates were provided by the Applicant's consultant. NMFS also examined hydroacoustic monitoring results for similar sized piles presented in the Compendium of Pile Driving Sound Data (Buehler *et al*. 2015, Appendix A) and generated estimates with a spreadsheet model to estimate peak SPLs and accumulated SELs at various distances from the source.

Table 4. Sound levels associated with impact hammer pile driving of 60-inch steel piles and 24-inch concrete piles.

Pile type and size	Max single strike peak at 33 feet (10 m)	Accumulated SEL at 33 feet (10 m)	Single strike RMS at 33 ft. (10 m)	Distance (ft.) to 206 dB peak	Distance (ft.) to 187 dB accumulated SEL/day	Distance (feet) to 150 dB RMS
60-inch steel*	200 dB	205 dB	185 dB	13	520	7,067
24-inch concrete	185 dB	160 dB	188 dB	N/A	37	707

*assumes use of a bubble curtain

The eight 60-inch diameter steel piles will only be used at one location; that is the Berth 4 loading platform. It is expected that one 60-inch pile would be installed per day and each 60-inch pile will require up to 1,000 blows for installation. Driving time of one 60-inch pile is estimated to be 2 hours. Thus, eight piles to be installed at 2 hours each, would generate up to 16 hours of elevated underwater sound levels over a period of eight days. The eight days of impact hammer operation for installation of the 60-inch piles will not be consecutive; it would be spread over an eight-week period in a single year during the period between June 1 and November 30.

Although the spreadsheet utilized by NMFS can predict sound pressure levels at a distance of less than 33 ft. (10 meters) from a pile, hydroacoustic measurements in the field generally cannot be made this close to a pile. Near-field effects of sound waves, on-site equipment, the air bubble curtain, and safety typically don't allow for hydroacoustic monitoring to be performed within a few feet of a pile. The spreadsheet model predicts the 206 dB peak single strike threshold is exceeded within 13 feet from a driven 60-inch diameter pile. However, at this close range, NMFS believes it is unlikely that sound pressure levels created by a single strike will result in the injury or mortality of green sturgeon and the basis for this finding is presented below.

Several factors make it unlikely that sturgeon will be present or injured in the area immediately adjacent to a pile being driven by the Project. First, the placement of an air bubble curtain will occupy 5-10 feet of the radial distance immediately outward from the pile. Air bubble curtains are constructed by the placement of one or more horizontal concentric rings of perforated tubing around the pile. Air is pumped through the tubes and into the rings to emit a curtain of bubbles that encapsulate the pile. To optimize the sound attenuation capability of the curtain the amount of bubbles and thickness of the curtain are maximized by adjusting the flow of compressed air delivered to the perforated tubing. Thus, equipment and the air bubble curtain itself will physically take up 5-10 feet immediately outward of the pile. Secondly, activation of the air bubble curtain immediately prior to the initiation of pile driving is expected to startle fish adjacent to the pile and likely result in a flight response. Additional noise will be created by the air compressors operating the bubble curtain, and boats and barges containing the pile driving equipment and crew will be operating immediately overhead on the water surface. This noise will likely be perceived by fish as a stimulus indicating potential danger in its immediate environment so sturgeon are not expected to remain in the area directly adjacent to a pile (greater than a 33-foot radial distance from the pile) during driving. Dolat (1997) reported a variety of fish species demonstrate an avoidance reaction in the near-field (*i.e.* immediately adjacent to the sound source) to underwater sounds. Dolat (1996) did not define "near-field" as a specific distance, but ICF Jones and Stokes and Illingworth and Rodkin Inc. (2009) use 33 feet (10 meters) for near-field effects and to estimate the area of acoustic impact. Thirdly, the short duration of the pile driving actions (up to 2 hours per day for up to 8 days) to install the pilings for the Project will also limit the amount of exposure incurred by green sturgeon in the action area.

Although it is unlikely sound levels associated with the single strike of an impact hammer on a 60-inch diameter pile will cause injury or mortality, cumulative SEL has the potential to result in injury or mortality of green sturgeon for a significantly greater distance from the pile. The spreadsheet model predicts the extent of SPLs above an accumulated SEL of 187 dB would extend up to a radial distance of approximately 520 feet (20 acres total) from the pile, and encompass the active working area under and around Berth 4. For the purposes of this analysis, the zone of potential injury or mortality to threatened green sturgeon is associated with accumulated SEL and is defined as the area in which fish could experience a range of barotraumas, including the damage to the inner ear, eyes, blood, nervous system, kidney, and liver. These injuries have the potential to result in the mortality of an individual fish either immediately or later in time.

Depending on the time of year, green sturgeon may be commonly found within San Pablo Bay, to the north of the project site, as indicated by the results of acoustic tag monitoring conducted by the California Fish Tagging Consortium. Tag monitoring results reported by Hearn *et al.* (2010) indicates that greater numbers of adult green sturgeon are detected in the summer and fall around the Golden Gate and up to the Carquinez Bridge. Of 47 tagged adult green sturgeon monitored between May 2009 and August 2010, one individual was detected at Richmond Point, adjacent to the action area, for a relatively brief period (*i.e.*, 22 minutes) (Hearn *et al.* 2010). To date, tagging studies provide little information on juvenile green sturgeon distribution and behavior, but sampling has indicated juveniles mostly occur in small groups in the Bay/Delta region (Adams *et al.* 2002, Hearn *et al.* 2010) and are unlikely to occur in more than small numbers in the action area. The action area of this Project provides sites with soft bottom substrate that is suitable for green sturgeon foraging.

Based on the foraging behavior and movements of green sturgeon within San Francisco Bay, some individuals may be subjected to elevated sound levels during pile driving activities at the Long Wharf. However, NMFS estimates that only a very small number of threatened Southern DPS green sturgeon may be injured or killed by the proposed pile driving because few individuals are likely to be exposed to an accumulated SEL of 187 dB or greater. To incur injury or mortality, an individual would need to remain continuously within the zone of accumulated SEL for an extend period of time during pile driving. For this Project, a green sturgeon would need to remain within 520 feet from the impact hammer during the 2-hour period of driving required to install a single 60-inch diameter steel pile. Over the full 5-year duration of the Project, installation of the eight 60-inch steel piles will occur for a total of 16 hours of pile driving spread out over a period of eight days (approximately 2 hours per day).

Within the zone of accumulated SEL of 187 dB at the Long Wharf (up to 520 feet from the pile being driven and an area of 20 acres), most exposed sturgeon are unlikely to remain in the same location to experience the full 2-hour duration of a 60-inch pile driving event due to tidal currents and behavioral movements. Thus, few, if any, sturgeon are expected to remain stationary long enough to accumulate SEL to levels which cause injury or mortality. Although no data are available to quantify the risk of exposure to the accumulated SEL threshold of 187 dB, NMFS believes that, for the reasons stated herein, the potential risk of injury and mortality to green sturgeon is low. Most sturgeon within the action area will be expected to temporarily disperse with this intrusion, or move with tidal currents and behavioral movements. The 20-acre zone of physical injury during pile driving is relatively small in comparison to the size of Central San Francisco Bay. Thus, the likelihood of an individual green sturgeon's presence in the area subject to exceedance of the cumulative SEL of 187 dB is low; the likelihood of injury or mortality is proportionate to the low likelihood of presence.

The Project also proposes to install 141 new 24-inch diameter concrete piles with an impact hammer. Estimates of elevated sound levels associated with installation of the 24-inch concrete piles are shown in Table 4. Up to two concrete piles may be installed per day, and each pile is anticipated to require one hour and 300 strikes for installation. Twenty four-inch diameter concrete piles will be used at all four berth sites at the Long Wharf and installation of this pile type will extend over the entire 5-year duration of the Project; although all pile installations will be limited to the period between June 1 and November 30.

Hydroacoustic monitoring has shown sound pressures associated with concrete piles are much lower than comparably sized steel piles (Buehler *et al.* 2015). Based on underwater sound level estimates provided by the Applicant and use of the NMFS spreadsheet model, elevated underwater sound levels associated with the installation of the Project's 24-inch concrete piles will not exceed the 206 dB peak single strike threshold at any distance from the pile (Table 4). For accumulated sound levels, the spreadsheet model estimates underwater sound levels generated by a full day of driving 24-inch concrete piles (two hours per day) would reach the cumulative SEL threshold of 187 dB at a distance of 37 ft. (11 meters) from the sound source. To reach this accumulated sound level, 600 blows with an impact hammer are required. As discussed above, it is unlikely green sturgeon will remain stationary in the immediately vicinity of an active pile installation event for the full duration of its installation. Each concrete pile will require 300 strikes to install and an individual green sturgeon must remain continuously within 37 feet of the first pile for 300 strikes and then within 37 feet of a second pile for another 300 strikes to be exposed to a cumulative SEL greater than 187 dB. Based on the estimated levels of underwater sound associated with installation of the Project's 24-inch diameter concrete piles, NMFS anticipates there will be no injury or mortality of green sturgeon during the installation of concrete piles by impact hammer.

All other piles proposed for installation by the Applicant (14-inch composite piles, 14-inch steel H-piles, and 24-inch steel piles) will be performed with a vibratory hammer. Vibratory hammers use counter-rotating eccentric weights to transmit vertical vibrations into the pile, causing the sediment surrounding the pile to liquefy and allow the pile to penetrate the substrate. The vibratory hammer produces sound energy that is spread out over time and is generally 10 to 20 dB lower than impact pile driving (Buehler *et al.* 2015). Based on the results of hydroacoustic monitoring of vibratory hammer pile installations (Buehler *et al.* 2015), the sound levels generated by vibratory hammer use at the Long Wharf will be considerably below the injury and mortality thresholds for both single strike and cumulative SEL, and no adverse effects to green sturgeon are anticipated.

Beyond the zone of potential injury or mortality, sound levels are projected to exceed 150 dB RMS to a maximum distance of 7,067 feet during the driving of 60-inch steel piles and a maximum distance of 707 feet during the driving of the 24-inch concrete piles. Fish may demonstrate temporary abnormal behavior within this zone during pile driving indicative of stress or exhibit a startle response. A fish that exhibits a startle response may not be injured, but is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. The behavioral impact zone is approximately 3,000 acres for the 60-inch diameter piles (Figure 2), and would be impacted for a period of 2 hours per day for a total 8 days of the Project. For installation of the 24-inch concrete piles, the behavioral impact zone is 35 acres. Impacts for this area would occur for two hours a day (2 piles per day) for 100 days and the 100 days would be spread out over the five-year construction period.

If any green sturgeon enter or transit the behavior impact zones described above during pile driving, there could be behavioral reactions. Green sturgeon may avoid the area due to the elevated underwater sound levels. As noted above, many fish species demonstrate an avoidance reaction in the near-field (Dolat 1997). While behavioral impacts to green sturgeon during pile

driving have not been specifically studied, NMFS anticipates that green sturgeon, like other fish studied, will exhibit startle and avoidance behavioral reactions. Due to the availability of estuarine habitat directly adjacent to the action area, and anticipated behavioral responses, green sturgeon are expected to react to the sound produced by pile driving by swimming away from the action area. Adequate water depths and the open water area of Central San Francisco Bay adjacent to the action area will provide startled fish sufficient area to escape and elevated sound levels should not result in significant effects on these individuals. Areas adjacent to the Project's action area provide habitat of similar or higher quality and provide adequate carrying capacity to support individual sturgeon that are temporarily displaced during the use of an impact hammer by the Project.

2.5.1.4 Assessment of Effects on Water Quality

Water quality in the action area may be degraded during the Project's construction activities. Disturbance of soft bottom sediments during the removal of existing piles and installation of new piles are expected to result in temporary increased levels of turbidity. Additionally, water quality may be degraded through the suspension of sediment-associated contaminants in the water column. The effects of elevated levels of turbidity and suspension of contaminants on green sturgeon as a result of pile removal and installation activities are presented below.

Turbidity

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, Nightingale and Simenstad 2001). There is little direct information available to assess the effects of turbidity in San Francisco Bay estuary on juvenile or adult green sturgeon. However, this benthic species is well adapted to living in estuaries with a fine sediment bottom and is tolerant of high levels of turbidity, because they have adapted to forage for prey organisms in soft bottom sediments.

As piles are driven and removed from the Bay floor by the Project, fine-grain sediments such as the clay and silt material found under and along the Long Wharf will be disturbed and generate increased levels of turbidity in the adjacent water column. The extent of turbidity plumes resulting from the Project construction will depend on the tide, currents, and wind conditions during pile driving activities.

Based on observations of similar pile removal and installation activities in San Francisco Bay, increased levels of suspended sediment and turbidity during pile driving by the Project are anticipated to be minor, localized, and short-term. With strong tidal currents in the action area, any elevated levels of suspended sediment or turbidity are anticipated to rapidly return to background levels after work ceases.

Based on the above, the extent and levels of turbidity associated with construction activities by the Project are not expected to result in harm or injury, or behavioral responses that impair migration, foraging, or make green sturgeon more susceptible to predation. If sturgeon temporarily relocate from areas of increased turbidity, habitat of similar value is available in Central San Francisco Bay adjacent to the action area, and other areas in San Francisco Bay offer

equal or better habitat value for displaced individuals. Adjacent habitat areas also provide adequate carrying capacity to support individual sturgeon that are temporarily displaced during in-water construction activities that cause increases in turbidity. For these reasons, the potential effects of minor and localized areas of elevated turbidity associated with this Project's construction activities are expected to be insignificant to green sturgeon.

Contaminants

As described above in the *Environmental Baseline*, water and sediment quality within the action area are affected by stormwater runoff, industrial activities, and other urban influences. Dillon and Moore (1990) reported that major pollutant sources for San Francisco Bay include the freshwater flow from the Sacramento-San Joaquin River systems, over 50 waste treatment plants, and about 200 industries which are permitted to discharge directly into the Bay (citing Luoma and Phillips 1988). Environmental contaminants discharged into aqueous systems tend to associate with particulate material in the water column and with consolidated bedded sediments. However, since the U.S. Environmental Protection Agency started the National Pollutant Discharge Elimination System in 1972, water quality in San Francisco Bay has improved considerably.

During the installation and removal of piles, bottom sediments will be suspended and contaminants may be released to the water column. However, based on the project description (including the type of activities conducted, the work span, and equipment used) the suspended plumes of sediment and potential contaminants released during construction are expected to be localized and short-term. Any minor and localized elevations in contaminants which might result from those suspended plumes are expected to be quickly diluted by tidal circulation to levels that are unlikely to adversely affect green sturgeon.

Equipment refueling, fluid leakage, equipment maintenance, and construction activities near open waters pose some risk of contamination of aquatic habitat and subsequent injury or death to green sturgeon. Oils and similar substances from construction equipment can contain a wide variety of PAHs and metals. Both can result in adverse impacts to green sturgeon. The Project will have in place a spill and prevention plan which is designed to avoid contamination from equipment refueling, leakage, maintenance or other activities. NMFS anticipates the Project's proposed measures to prevent contamination will adequately protect water quality and avoid adverse effects by contaminants on green sturgeon.

2.5.1.5 Assessment of Effects on Critical Habitat

The action area is designated as critical habitat for Southern DPS green sturgeon and Project implementation is anticipated to impact designated critical habitat. Construction activities are expected to temporarily alter water quality and foraging habitat for green sturgeon designated critical habitat.

Water Quality

The effects of Project construction activities on water quality are discussed above in section 2.5.1.4, Assessment of Effects on Water Quality, of this biological opinion and also apply to designated critical habitat in the action area. As described above, the effects of the proposed

Project may result in increased levels of turbidity and the suspension of sediment-associated contaminants. The impacts on water quality from turbidity and contaminants are not expected to degrade PBFs of green sturgeon because the level of potential contaminant exposure is low and elevated turbidity is expected to be short-term, minor, and localized.

Disturbance of the Benthic Community

The Project's installation and removal of pilings will disturb bottom sediments and disturb the associated benthic community in the action area. Benthic invertebrates that are directly in the footprint of the 201 new piles may be injured or killed. Although information on green sturgeon foraging behavior and their prey organisms in the San Francisco Estuary is limited, it is known that green sturgeon prey on demersal fish and benthic invertebrates in estuaries. 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).

Pile driving by this Project is expected to remove some prey organisms for green sturgeon and foraging by sturgeon in the action area may be affected. However, the extent of impacts to the benthic community is expected to be small due to the very small area affected by an individual pile and that each site of pile installation is non-contiguous from another. Based on recovery rates for benthic disturbance in the scientific literature (Oliver *et al.* 1977, Watling *et al.* 2001) and the extended schedule for Project construction, impacts to the benthic community in the action area are expected to extend over the full 5-year period of the Corps authorization. Collie *et al.* (2000) reported some aquatic invertebrates re-colonize areas within a few months of a disturbance activity and this is expected at individual sites following the completion of pile installation.

Due to several factors, NMFS does not expect the temporary reduction of benthic prey in the action area will prevent sturgeon from finding suitable forage at the quantities and quality necessary for normal behavior (*e.g.,* maintenance, growth, reproduction). First, the area of benthic disturbance due to new permanent pile installation is a small portion of the action area (total of 777 square feet). Secondly, many benthic organisms are likely to survive the disturbance associated with Project construction. Thirdly, all pile driving and pile removals will occur under or immediately adjacent to the existing Long Wharf which is an area highly modified by maritime development and frequent dredging. Given the small portion of the action area disturbed, the likely availability of forage elsewhere in the action area, and the recovery of the benthic community after disturbance, impacts to prey resource availability due to Project construction are expected to be insignificant.

Reduced Use of Action Area during Pile Driving

As described above in section 2.5.1.3 of this biological opinion, elevated SPLs within the action area are expected to create a zone of behavioral impacts (*i.e.* sound levels greater than 150 dB RMS) that may result in a level of disturbance that causes green sturgeon to avoid using the area for foraging and migrating during pile driving. Assuming the worst case scenario, elevated sound levels result in an adverse behavioral response during pile driving, and the action area is rendered unusable by green sturgeon during hours when pile driving operations are underway.

For the Project's use of an impact hammer to install 60-inch steel piles, the area of behavioral effects may be as large as 3,000 acres surrounding Berth 4 and this area may be avoided by green sturgeon for 2 hours a day for a total eight days. The area of behavioral effects is projected to be approximately 35 acres during the installation of the Project's 24-inch concrete piles and this zone may be avoided by green sturgeon for 2 hours a day for a total of 100 days over the 5-year period of Project construction.

The action area is thought to provide foraging habitat for sturgeon because the site includes soft bottom subtidal habitat. Although pile driving will not exceed 2 hours on any one day, this temporal loss of foraging area could be an adverse effect on PBFs for food resources/prey. During the 2-hour period of pile driving over the Project's 108 days of pile driving activities, green sturgeon may avoid foraging in portions of the action area. However, when each day's pile driving activities have concluded, this area and its food resources will again be fully accessible to green sturgeon. Due to the short duration of a single pile driving episode (*i.e.*, up to 2 hours per day), this temporary impact is not anticipated to prevent sturgeon from finding suitable forage at the quantities and quality necessary for normal behavior (*e.g.,* maintenance, growth, reproduction).

If sturgeon do avoid foraging in the area of behavioral effects during pile driving, areas adjacent to the Project's action area provide habitat of similar quality. Based on the number of acres of aquatic habitat in Central San Francisco Bay (45,000 acres), during the 16 hours of installation of eight 60-inch piles, approximately 7 percent of the aquatic habitat in the Central Bay (*i.e.*, 3,000 acres) may be rendered temporarily unusable. For the Project's 24-inch piles, the zone of behavioral effects is expected to extend over 35 acres which would render approximately 0.08 percent of the aquatic habitat in Central San Francisco Bay unusable for a total of 200 hours over a 5-year period. When all of the Project's pile driving activities have been completed, NMFS does not expect any lasting reduction in habitat value related to elevated sound levels from pile driving.

Upstream and downstream passage of green sturgeon through Central San Francisco Bay could be adversely affected during the installation of the Project's 60-inch pile because the area of behavioral effects extends approximately 7,067 feet from the Project site towards the Tiburon Peninsula on the west side of the Bay. This distance represents approximately one-third of the channel width at this location in the Bay and this temporal impact could be an adverse effect on PBFs of the migratory corridor for safe and timely passage. Migrating green sturgeon attempting to pass through the zone of behavioral effects during the 2-hour period of 60-inch pile driving may temporarily stop migrating or shift their migration path to the western portion of the Central Bay. This delay or shift in migration could extend up to 2-hours a day, but would be limited to a total of eight days in a single year of the 5-year Project. Due to the short duration of a single pile driving episode (*i.e.*, up to 2 hours per day), this temporary delay or shift in migration pathway is not anticipated to prevent sturgeon from completing their migrations through the Bay or prevent them from moving to areas with suitable forage. During the installation of the Project's 24-inch piles, the zone of behavioral effects is expected to extend approximately 707 feet from the pile being driven; thus, no effects to migrating sturgeon are anticipated because the area represents a very small fraction of the channel width across Central San Francisco Bay.

When analyzing the behavioral effects of pile driving on fish, it is also important to consider ambient sound levels in the action area. The distance at which generated underwater sound levels attenuate to ambient level would generally be considered the area of potential behavioral effects. In San Francisco Bay, ambient sound levels are reported to range from 120-155 dB peak (Strategic Environmental Consulting, Inc. 2004, as reported in Buehler *et al.* 2015). Thus, ambient sound levels in the action area are likely similar at times to the 150 dB RMS levels anticipated to occur inside the zone of behavioral effects during pile driving. With this level of ambient sound in the environmental setting of Central San Francisco Bay, elevated sound levels due to this Project's pile driving within the zone of behavioral effects may be hard to distinguish from other anthropogenic sources of sound, such as commercial vessels and recreational boats. Thus, it is unclear if sound levels of 150 dB RMS originating from pile driving by this Project will result in an avoidance response by green sturgeon.

Overwater Shading

Implementation of the Project will increase the footprint of overwater structures in the action area by 4,832 sq. ft. Overwater structures, such as docks and piers, are known to reduce growth of submerged aquatic vegetation, decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, and reduce the density of benthic invertebrates (Helfman 1981, Glasby 1999, Struck *et al.* 2004, Stutes *et al.* 2006); all of which may lead to an overall reduction in the quality of fish habitat. Light reduction decreases the amount of energy available for photosynthesis by phytoplankton, benthic algae, and attached microalgae. These are important components of food webs supporting juvenile and adult green sturgeon.

For the Long Wharf Project, the increase in overwater structure is not contiguous, which breaks up the amount of new shading. Additionally, the Long Wharf is oriented north/south within 45 degrees, which minimizes the amount of time the space under the dock is left shaded during the day. The area affected by the increase in overwater structure in the action area will be limited to sites immediately adjacent to the Long Wharf which are subtidal habitat that is regularly dredged for navigation and disturbed by large vessel traffic. Due to this regular disturbance and water depths ranging from 20-40 feet, it is unlikely that submerged aquatic vegetation will become established in these subtidal areas. For the above reasons, the creation of new overwater structure on the Long Wharf is not expected to degrade PBFs of designated critical habitat in the action area.

2.6 Cumulative Effects

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

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

environmental conditions in the action area are described in the environmental baseline (Section 2.4).

2.7 Integration and Synthesis

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

Southern DPS green sturgeon have experienced serious declines in abundance and long-term population trends that suggest a negative growth rate. Human-induced factors have reduced populations and degraded habitat, which in turn has reduced the population's resilience to natural events, such as droughts, floods, and variable ocean conditions. Global climate change presents another real threat to the long-term persistence of the population, especially when combined with the current depressed population status and human caused impacts. Within the Project's action area in Central San Francisco Bay, the effects of shoreline development, industrialization, and urbanization are evident. As a result, forage species that green sturgeon depend on have been reduced throughout the greater San Francisco Bay Estuary.

During construction activities at the Long Wharf, water quality in the action area is expected to be degraded through the disturbance of bottom sediments as existing piles are removed and new piles installed. Elevated levels of turbidity and the suspension of sediment associated contaminants in the water column are anticipated and may result in temporary changes to fish behavior, but are not expected to adversely affect green sturgeon.

Threatened green sturgeon may be adversely affected by elevated underwater sound levels during the driving of large (*i.e.*, 60-inch diameter) steel piles with an impact hammer. With the proposed use of an air bubble curtain to attenuate underwater sound levels, peak SPLs above 206 dB from a single strike will be limited to the area immediately adjacent to the pile (up to 13 feet from the pile). It is unlikely individual sturgeon will occur within this close in proximately during construction activities since equipment is expected to startle fish away from the pile driving sites before pile driving initiates and a bubble curtain will likely prevent fish from being located within 13 feet of the piles. However, accumulated SELs may result in injury or death to green sturgeon if individuals remain within a distance of 520 feet from the piles being driven for an extended period. NMFS expects the number of green sturgeon exposed to this effect to be small because the duration of pile driving is short (up to 2 hours per day for a period of 8 days), the zone of physical injury is immediately adjacent to the marine terminal facility, and the abundance of green sturgeon in the action area expected to be low. Behavioral effects during the driving of the 60-inch piles may extend up to 7,067 feet for a period of up to 2 hours per day. This noise may discourage green sturgeon from utilizing the action area for foraging or passage

during pile driving, but this area represents a small portion of the Central San Francisco Bay and these habitat areas will become available again once the 60-inch pile driving is completed.

Installation of the Project's smaller 24-inch concrete piles by impact hammer will extend for a period of approximately 100 days over the 5-year duration of the Project. The Applicant estimates the 24-inch concrete piles will also require about 2 hours of pile driving per day. Elevated sound levels during the installation of the concrete piles will not exceed the 206 dB peak single strike threshold at any distance from the pile. For accumulated sound levels, underwater sound levels generated by a full day of driving two 24-inch concrete piles would reach the cumulative SEL threshold of 187 dB at a distance of 37 ft. from the sound source. To reach this accumulated sound level, 600 blows with an impact hammer are required during two full pile installations. It is unlikely green sturgeon will remain stationary in the immediately vicinity (< 37 feet) of two separate pile installation events; thus, NMFS anticipates there will be no injury or mortality of green sturgeon during the installation of concrete piles by impact hammer.

The action area is designated critical habitat for Southern DPS green sturgeon. Critical habitat is expected to be impacted through temporary degradation of water quality and temporary impacts to foraging habitat. Water quality may be degraded through increased turbidity and suspension of sediment-borne contaminants. Foraging habitat will be temporarily affected during Project activities through elevated SPLs, physical disturbance of benthic habitat, and the associated impacts to food resources. Once the pile driving is complete, temporary impacts from elevated SPLs will cease. Temporary impacts from the small areas of benthic habitat disturbed by the removal and placement of piles are expected to recover rapidly due to the small footprint of individual piles.

Based on the above, a small number of green sturgeon could be adversely affected by the Project's proposed pile driving activities. However, it is unlikely that the small potential loss of individuals as a result of the Project will impact future adult returns due to the large number of green sturgeon unaffected by the Project compared to the small number of sturgeon likely affected by the Project. Due to the life history strategy of green sturgeon that spawn every 3-5 years over an adult lifespan of as much as 40 years (Moyle 2002), the few individuals injured or killed during pile driving are likely to be replaced in subsequent generations of green sturgeon.

Regarding future climate change effects in the action area, California could be subject to higher average summer air temperatures and lower total precipitation levels. Reductions in the amount of snowfall and rainfall would reduce stream flow levels in Northern and Central Coastal rivers. Estuaries may also experience changes in productivity due to changes in freshwater flows, nutrient cycling, and sediment amounts. For this Project, in-water activities will occur from 2018 to 2023, and the above effects of climate change are not likely to be detected within that time frame. If the effects of climate change are detected, they will likely materialize as moderate changes to the current climate conditions within the action area. These changes may place further stress on green sturgeon populations. The effects of the proposed action combined with moderate climate change effects may result in conditions similar to those produced by natural ocean-atmospheric variations (as described in the Environmental Baseline) and annual variations. The species are expected to persist throughout these phenomena, as they have in the

past, even when concurrently exposed to the effects of similar projects.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the Chevron Long Wharf Maintenance and Efficiency Project is not likely to jeopardize the continued existence of threatened Southern DPS green sturgeon or destroy or adversely modify its designated critical habitat.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS that incidental take is reasonably certain to occur as follows: NMFS anticipates that the take of threatened green sturgeon associated the Chevron Long Wharf Maintenance and Efficiency Project in Central San Francisco Bay, Alameda County, California will be in the form of injury or mortality to green sturgeon caused by impact hammer pile driving.

Due to the relatively small area of potential effect and its location under water with low visibility, NMFS was not able to estimate the specific number green sturgeon that may be in the action area during the proposed action. Monitoring or measuring the number of listed fish actually injured or killed by elevated sound levels during pile driving is also not feasible. Observation of injured or killed fish is unlikely because they may not float to the surface or may be carried away by the strong currents in and near the action area into the larger portions of Central San Francisco Bay. Due to the difficulty in quantifying the number of listed green sturgeon that could be affected by pile driving, a surrogate measure of take is necessary to establish a limit to take the exempted by this incidental take statement. For this action, compliance with the expected elevated underwater sound levels during pile driving is the best surrogate measure for incidental take associated with Project implementation. Therefore, NMFS will consider the extent of take exceeded if elevated sound levels during pile driving indicates

that accumulated sound pressure levels greater than 187 dB SEL extend beyond 520 feet during the installation of any of the 60-inch steel piles. During the driving of the 24-inch concrete piles, NMFS will consider the extent of take exceeded if elevated sound levels during pile driving indicates that accumulated sound pressure levels greater than 187 dB SEL extend beyond 37 feet. These distances represent the maximum area where green sturgeon injury or death is reasonably certain during pile driving for this project.

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

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

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of green sturgeon:

1. Hydroacoustic monitoring shall be performed during the driving of all 60-inch piles to evaluate Project effects on green sturgeon.

2. Prepare and submit plans and reports regarding the construction of the proposed Project and the results of hydroacoustic monitoring.

2.9.4 Terms and Conditions

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

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

    a. Chevron shall conduct hydroacoustic monitoring as described in the Project's hydroacoustic monitoring plan during the installation of all eight 60-inch diameter steel piles.

    b. Chevron shall fully implement the Project's hydroacoustic monitoring plan and make available to NMFS data from the hydroacoustic monitoring program on a real-time basis (*i.e.,* daily monitoring data should be accessible to NMFS upon request).

c. Chevron shall allow any NMFS employee(s) or any other person(s) designated by NMFS to accompany field personnel to visit the Project site during the activities described in this opinion.

d. If any sturgeon are found dead or injured during visual observations, the biologist shall contact NMFS biologist Sara Azat by phone immediately at (707) 575-6067 or the NMFS North Central Coast Office at (707) 575-6050. All sturgeon mortalities shall be retained, placed in an appropriately-sized sealable plastic bag, labeled with the date and location of collection, fork length, and be frozen as soon as possible. Frozen samples shall be retained by the biologist until specific instructions are provided by NMFS. The biologist may not transfer biological samples to anyone other than the NMFS North Central Coast Office without obtaining prior written approval from the NMFS North Central Coast Office. Any such transfer will be subject to such conditions as NMFS deems appropriate.

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

a. The Corps or Chevron shall provide written annual reports to NMFS by January 15 of each year until the Project has been completed, and a final report post-construction by January 15 of the year following Project completion. The report shall be submitted to NMFS North Central Coast Office, Attention: San Francisco Bay Branch Supervisor, 777 Sonoma Avenue, Room 325, Santa Rosa, California 95404-6528. The report must contain, at a minimum, the following information:

i. **Project related activities** – (1) dates pile removal and installation occurred during each year of the Project; (2) a description of any and all measures taken to minimize effects on green sturgeon (*e.g.*, utilization of bubble curtain or vibratory hammer); and (3) any fish observed to be injured or killed during Project activities.

ii. **Hydroacoustic monitoring** – (1) a description of the methods used to monitor sound; (2) the dates that hydroacoustic monitoring was conducted; (3) the locations (depths and distance from point of impact) where monitoring was conducted, (4) the total number of pile strikes per pile, (5) total number of strikes per day, (6) the interval between strikes, (7) the peak/SPL, RMS and SEL per strike, and (8) accumulated SEL per day.

2.10 Conservation Recommendations

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

NMFS recommends Chevron expand the Project's hydroacoustic monitoring plan to include at least 35 percent of the 24-inch diameter concrete piles. This additional monitoring data will

expand our knowledge base regarding the hydroacoustic effects of pile driving in San Francisco Bay and refine our ability to predict elevated underwater sound levels associated with impact hammers.

2.11 Reinitiation of Consultation

This concludes formal consultation for Chevron Long Wharf Maintenance and Efficiency Project.

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

2.12 "Not Likely to Adversely Affect" Determinations

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (50 CFR 402.02). The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur.

NMFS does not anticipate the proposed action will adversely affect:

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) Evolutionarily Significant Unit **(ESU)**
endangered (70 FR 37160; June 28, 2005)
critical habitat (58 FR 33212; June 16, 1993);
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) **ESU**
threatened (70 FR 37160; June 28, 2005);
Central California Coast steelhead (*Oncorhynchus mykiss*) **DPS**
threatened (71 FR 834; January 5, 2006);
critical habitat (70 FR 52488; September 2, 2005); and
Central Valley steelhead (*Oncorhynchus mykiss*) **DPS**
threatened (71 FR 834; January 5, 2006).

The effects of the proposed action are reasonably likely to include elevated underwater sound levels during pile driving, temporary degradations to water quality, increased shading of aquatic habitat, and habitat disturbance as described above. By restricting pile driving activities to the

period between June 1 and November 30, the project avoids the majority of the migration seasons of adult and juvenile ESA-listed salmonids in Central San Francisco Bay. Thus, NMFS anticipates ESA-listed anadromous salmonids are unlikely to be present in the action area during the Project's in-water construction activities.

Use of an impact hammer to install steel and concrete piles are anticipated to generated elevated levels of underwater sound during construction of the Long Wharf Project. The hydroacoustic effects of the Project's pile driving activities are described in section 2.5.1.3. However, the effects on fish associated with elevated sound pressure levels only occur during the pile driving events and effects will cease when operation of the pile driving hammer is terminated. With the Project's in-water work activities restricted to the period of June 1 through November 30, listed anadromous salmonids will not be present in the action area to experience elevated underwater sound levels and the temporary effects of pile driving will have concluded prior to the seasonal presence of listed salmonids in the action area.

Effects to water quality associated with Project activities are described in section 2.5.1.4. As with elevated sound levels during pile driving, effects of degraded water quality are anticipated to cease prior to the seasonal occurrence of listed anadromous salmonids in the action area. Pile removal and pile installation will likely create temporary increases in turbidity and may suspend sediment-associated contaminants into the adjacent water column. However, these effects to water quality are expected to rapidly dissipate with tidal circulation when the work ceases. With the Project's in-water work activities restricted to the period of June 1 through November 30, listed anadromous salmonids will not be present to experience degraded water quality conditions in the action area. Based on the above, the effects of the Project's construction activities on listed anadromous salmonids are anticipated to be discountable.

The action area is designated as critical habitat for Sacramento River winter-run Chinook salmon, and CCC steelhead. The PBFs essential for the conservation of Sacramento River winter-run Chinook salmon are: (1) access from the Pacific Ocean to appropriate areas in the upper Sacramento river, (2) availability of clean gravel for spawning substrate, (3) adequate river flows for spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5 °F (5.8 and 14.1 °C) for successful spawning, egg incubation, and fry development, (5) habitat areas and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from spawning grounds to San Francisco Bay and the Pacific Ocean. PBFs of designated critical habitat for CCC steelhead include estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The Project's installation and removal of pilings will disturb bottom sediments and the associated benthic community in a small portion of the Project's action area (approximately 777 square feet). This disturbance may injure or kill benthic organisms, some of which may be prey for listed salmonids. However, once construction activities are completed, the benthic

community in disturbed areas is expected to recover rapidly due to the small footprint of each pile. Collie *et al.* (2000) reported some aquatic invertebrates re-colonize areas within a few months of a disturbance activity. Because of the small size of disturbed areas (directly under and adjacent to pilings removed or installed), NMFS expects that the effects of disturbance to the benthic community from this Project's pile driving will be minor and not affect foraging by listed salmonids. Water depths at the pile installation sites range from 20-40 feet and this is below the typical foraging depths of salmonids. Based on the above, effects of benthic disturbance on foraging by listed salmonids within the action area are expected to be insignificant.

As described in section 2.5.1.5, the Project will have a net increase of 4,832 square feet (0.11 acre) in overwater shading. Overwater structures are known to reduce growth of submerged aquatic vegetation, decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, and reduce the density of benthic invertebrates (Helfman 1981, Glasby 1999, Struck *et al.* 2004, Stutes *et al.* 2006). At the Long Wharf, the Project's expansion of overwater structure is not in one location or contiguous, and the overall orientation of the Long Wharf is in a north/south orientation that minimizes the effects of shading. Additionally, the site is located in water depths of 20 to 40 feet and subject to regular disturbance by vessel traffic and dredging. Based on the highly modified condition of aquatic habitat at the Long Wharf, the expanded area of overwater structure created by the Project is not expected to degrade PBFs of designated critical habitat for listed salmonids in the action area. For the above reasons, the potential effects of the Project are considered insignificant or discountable and are not expected to result in either a net change to existing habitat values in the action area or result in adverse impacts to designated critical habitat for listed salmonids.

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

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

This analysis is based, in part, on the EFH assessment provided by the Corps and descriptions of EFH for Pacific coast groundfish (Pacific Fishery Management Council [PFMC] 2005), coastal pelagic species (CPS)(PFMC 1998), Pacific coast salmon (PFMC 1999) contained in the fishery management plans (FMP) developed by the PFMC 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 EFH will occur through (1) increased turbidity in the water column, (2) suspension of sediment-associated contaminants, (3) disturbance of benthic habitat, including the associated biological community, and (4) increase in shading of aquatic habitat. EFH will also be temporarily impacted by elevated underwater sound levels during pile driving.

Turbidity

In-water work activities (pile removal and installation) may result in elevated levels of turbidity and suspended sediment in the water column (section 2.5.1.4). The finer grain sediments, silts and clays, are more readily suspended and settle out slower than course sediments, such as sand and gravel. In-water work in areas with fine sediments are likely to have greater turbidity impacts than in areas with coarse sediments (Sabol *et al.* 2005). The action area is expected to have a primarily fine grain sediments with only a minimal amount of sand and gravel.

The frequency and duration of elevated turbidity generally depends upon the size and quality of the bottom sediments and the frequency and duration of the activity. Elevated levels of turbidity are expected during pile removal and installation activities. However, not all pile removal and installation will take place concurrently, and the areas of Project activities where increased turbidity will occur are relatively small. Therefore, in-water work is expected to have localized and short-term periods of elevated turbidity that dissipate with tidal circulation.

Release of Contaminants

The suspension of contaminated sediments during pile installation and removal activities presents the potential for release of contaminants to the water column, and for the uptake of contaminants by organisms contacting re-suspended material (section 2.5.1.4). However, most contaminants are tightly bound in the sediments and are not easily released during short-term resuspension (USACE 2004). Long-term impacts may be associated with newly exposed sediment. Residuals contribute to long-term risk at the site, including bioaccumulative risk, if they are sufficiently thick and extensive (USACE *et al.* 2009). Any residual toxic metals and organic contaminants absorbed or adsorbed to fine-grained particulates in the surface layer of sediment may become available to organisms either in the water column or through food chain processes. Sediment and sampling analysis results done in July 2015 for maintenance dredging at the Long Wharf indicated that sediments at Berths 1-4 do not exceed sediment contaminant testing thresholds or bioaccumulation triggers (Arcadis 2016).

This Project does not include any activities that will disturb large surface areas on the bay floor. This will avoid the creation of newly exposed surface layers of sediment that allow for contaminants to be made available to organisms and assimilation into the food chain.

Furthermore, the potential for suspension of contaminated sediment is low with this Project as the area of disturbed sediment is small.

Benthic disturbance

Pile removal and installation is expected to disturb the benthic community in the action area (section 2.5.1.5). This disturbance will impact forage species, such as infaunal and bottom-dwelling organisms like polychaete worms and crustaceans, by directly contacting or burying these organisms (Newell *et al.* 1998, Van der Veer *et al.* 1985). Recolonization studies suggest that recovery may not be linear, and can be regulated by physical factors including particle size distribution, currents, and compaction/stabilization processes following disturbance. Rates of recovery listed in the literature range from several months to several years for estuarine muds (Oliver *et al.* 1977, Currie and Parry 1996, Tuck *et al.* 1998, Watling *et al.* 2001) and can take up to 1 to 3 years in areas of strong currents (Oliver *et al.* 1977). At the Long Wharf, benthic organisms are expected to recover rapidly at disturbed sites due to the small footprint of each pile. Collie *et al.* (2000) reported some aquatic invertebrates re-colonize areas within a few months of a disturbance activity. Because of the small size of disturbed areas (directly under and adjacent to pilings removed or installed), NMFS expects that the effects of disturbance to the benthic community from this Project's pile removal and installation will be minor.

Shading of Aquatic Habitat

The Project will have a net increase of 4,832 sq. ft. (0.11 acre) in overwater shading. As discussed in sections 2.5.1.5, and 2.12 above, overwater structures are known to reduce growth of submerged aquatic vegetation, decrease primary productivity, alter predator-prey interactions, change invertebrate assemblages, and reduce the density of benthic invertebrates (Helfman 1981, Glasby 1999, Struck *et al.* 2004, Stutes *et al.* 2006); all of which may lead to an overall reduction in the quality of EFH. At the Long Wharf, the Project's increase in overwater structure is non-contiguous, and oriented north/south which will minimize overwater shading effects. Further, in order to offset the impacts of shading on aquatic habitat associated with the increase in Long Wharf overwater structure and fill, the Applicant has contributed $220,000 to the State Coastal Conservancy for removal of 4,971 sq. ft. of piles and overwater structure at Terminal Four in Richmond, California. This Project was originally reviewed in a concurrence letter with the Corps dated June 15, 2010. The Project is planned for implementation in the fall of 2018. The removal of overwater structure and pilings at Terminal Four in Richmond is expected to improve aquatic habitat conditions at Richmond by increasing the amount of light in the water column and energy available for photosynthesis by phytoplankton, benthic algae, and attached microalgae.

Elevated Underwater Sound Levels

Pile driving will increase underwater sound pressures and will effect open water column habitat for fishes. Approximately 3000 acres of Central San Francisco Bay will be impacted for 2 hours a day for eight days by the installation of the 60-inch steel piles, and 35 acres will be impacted for 2 hours a day for 100 days over a 5-year period during the pile driving of the 24-inch concrete piles. However, it is expected that fish will utilize other adjacent habitats during pile driving activities and the elevated sound pressure levels will have no permanent impact on EFH.

3.3 Essential Fish Habitat Conservation Recommendations

There are no practical EFH Conservation Recommendations to provide because impacts to EFH are expected to minor, temporary, localized, or addressed through proposed mitigation.

3.4 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are The U.S. Army Corp of Engineers. Other interested users could include Chevron, U.S. Fish and Wildlife Service, San Francisco Bay Conservation and Development Commission, and the State Water Quality Control Board. Individual copies of this opinion were provided to the Corps. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

5. REFERENCES

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

Adams, P.B., C.B. Grimes, S.T. Lindley, and M.L. Moser. 2002. Status Review for North American Green Sturgeon, *Acipenser medirostris*. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 49 pages.

Adams, P.B., C.B. Grimes, J.E. Hightower, S.T. Lindley, M.L. Moser, and M.J. Parsley. 2007. Population status of North American green sturgeon, *Acipenser medirostris*. Environmental Biology of Fishes 79:339-356.

Arcadis. 2016. Sediment Sampling and Analysis Results. USACE Permit No. 2009-0052S, Dredge Episode No. 7. July. Chevron Refinery Long Wharf, Richmond, California. http://www.dmmosfbay.org/site/alias__8911/170140/default.aspx

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

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

Brewer, P. G., and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO2 Problem. Scientific American. http://www.scientificamerican.com/article/rising-acidity-in-the-ocean/.

Buehler, D., R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015 Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Prepared for California Department of Transportation, 1120 N Street, Sacramento, CA

95814. November 2015.

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

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California. 79 pages, plus appendices.

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

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

Currie, D.R., and Parry, G.D. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. Oceanographic Literature Review 43(12).

Dillon, T.M., and D.W. Moore. (1990). Assessment of dredged material toxicity in San Francisco Bay. Miscellaneous Paper EL-90-20, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Dolat, S.W. 1997. Acoustic measurements during the Baldwin Bridge Demolition (Final, dated March 4, 1997). Waterford, CT. 34 pp + appendices. Prepared for White Oak Construction by Sonalysts, Inc.

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

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

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, F.J. Millero. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the oceans. Science 305:362-366.

Fewtrell, J.H. 2003. The response of finfish and marine invertebrates to seismic survey noise. Thesis presented for the degree of Doctor of Philosophy, Curtin University of Technology. Muresk Institute. October 2003, 20 pages.

FHWG (Fisheries Hydroacoustic Working Group). 2008. Agreement in Principle for the Interim Criteria for Injury to Fish from Pile Driving Activities. The Fisheries Hydroacoustic Working Group. June 12, 2008.

Glasby, T.M. 1999. Effects of shading on subtidal epibiotic assemblages. Journal of Experimental Marine Biology and Ecology 234:275-290.

Goals Project. 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2015, prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

Hastings, M. C. 1995. Physical effects of noise on fishes. Proceedings of INTER-NOISE 95, The 1995 International Congress on Noise Control Engineering, Volume II: 979–984.

Hastings, M.C., and A.N. Popper. 2005. Effects of sound on fish. Jones and Stokes, Sacramento, CA.

Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, Miller NL, Moser SC, Schneider SH, Cahill KN, Cleland EE, Dale L, Drapek R, Hanermann RM (2004) Emissions pathways, climate change, and impacts on California. Proc Natl Acad Sci USA 101(34):12422–12427 24 August 2004

Hearn, A.R., E.D. Chapman, A.P. Klimley, P.E. LaCivita, and W.N. Brostoff. 2010. Salmonid smolt outmigration and distribution in the San Francisco Estuary 2010. Interim Draft Report, University of California Davis and US Army Corp of Engineers. 90 pages.

Helfman, G.S. 1981. The advantage to fishes of hovering in shade. Copeia 2:392-400.

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

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

ICF Jones and Stokes and Illingworth and Rodkin Inc. 2009. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish – Final. Prepared for: California Department of Transportation: 298.

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

Israel, J.A. and B. May. 2010. Indirect genetic estimates of breeding population size in the polyploidy green sturgeon (*Acipenser medirostris*). Molecular Ecology 19:1058-1070.

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

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

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

Lindley, S. T., R.S. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B. May, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lindley, S.T., M.L. Moser, D.L. Erickson, M. Belchik, D.W. Welch, E.L. Rechisky, D. Vogel, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2008. Marine Migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182–194.

Lindley, S.T., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey Jr., M. Belchik, D. Vogel, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108-122.

Lombarte, A., H.Y. Yan, A.N. Popper, J.C. Chang, and C. Platt. 1993. Damage and regeneration of hair cell ciliary bundles in a fish ear following treatment with gentamicin. Hearing Research 66:166-174.

Luoma, S.N., and D.J.H. Phillips. 1988. Distribution, variability, and impacts of trace elements in San Francisco Bay. Marine Pollution Bulletin 19(9):413-425.

Moyle, P.B. 1976. Inland fishes of California: First Edition. University of California Press. Berkeley, Los Angeles and London. 405 pages.

Moyle, P.B. 2002. Inland fishes of California: Second edition. University of California Press, Berkeley and Los Angeles, CA. 502 pages.

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

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and growth of Klamath River green sturgeon (*Acipenser medirostris*). U.S. Fish and Wildlife Service Project 93-FP-13, Yreka, CA. 20 pages.

Newell, R.C., L.J. Seiderer, and D.R. Hitchcock. 1998. The impact of dredging on biological resources of the sea bed. Oceanography and Marine Biology Annual Review 336:127-178.

Nelson, T.C., P. Doukakis, S.T. Lindley, A.D. Schreier, J.E. Hightower, L.R. Hildebrand, R.E.

Whitlock, and M.A.H. Webb. 2010. Modern technologies for an ancient fish: tools to inform management of migratory sturgeon stocks. A report for the Pacific Ocean Shelf Tracking (POST) Project.

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

NMFS (National Marine Fisheries Service). 2005. Green sturgeon (*Acipenser medirostris*) status review update. Biological review team- Southwest Fisheries Science Center, Santa Cruz.

NMFS (National Marine Fisheries Service). 2015. Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*) 5-Year Review: Summary and Evaluation. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region, Long Beach, California. 42 pages.

Oliver, J.S., P.N. Slattery, L.W. Hulberg, and J.W. Nybakken. 1977. Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. U.S. Army Corps of Engineers. Technical Report D-77-27.

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

PFMC (Pacific Fishery Management Council). 1998. Description and identification of essential fish habitat for the Coastal Pelagic Species Fishery Management Plan. Appendix D to Amendment 8 to the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council, Portland, Oregon. December.

PFMC (Pacific Fishery Management Council). 1999. Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. Appendix A to Amendment 14 to the Pacific Coast Salmon Plan. Pacific Fishery Management Council, Portland, Oregon. March.

PFMC (Pacific Fishery Management Council). 2005. Amendment 18 (bycatch mitigation program), Amendment 19 (essential fish habitat) to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery. Pacific Fishery Management Council, Portland, Oregon. November.

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

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon. Pages 115-129 *in*:

J.L. Turner and D.W. Kelley, editors. Ecological studies of the Sacramento-San Joaquin Delta Part II: Fishes of the Delta. California Department of Fish and Game Fish Bulletin.

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

Sabol, B., D. Shafer, and E. Lord. 2005. Dredging effects on Eelgrass (*Zostera marina*) distribution in a New England small boat harbor. Final Report ERDC/EL TR-05-8. U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS.

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

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

Schneider, S.H. 2007. The unique risks to California from human-induced climate change.

Shin, H.O. 1995. Effect of the piling work noise on the behavior of snakehead (*Channa argus*) in the aquafarm. Journal of the Korean Fisheries Society 28(4):492-502.

Smith, M.E., A.B. Coffin, D.L. Miller, and A.N. Popper. 2006. Anatomical and functional recovery of the goldfish (*Carassius auratus*) ear following noise exposure. Journal of Experimental Biology 209:4193-4202.

Smith, D.M., S. Cusack, A.W. Colman, C.K. Folland, G.R. Harris, J.M. Murphy. 2007. Improved Surface Temperature Prediction for the coming Decade from a Global Climate Model. Science 317(5839):796-799.

Struck, S.D., C.B. Craft, S.W. Broome, M.D. Sanclements and J.N. Sacco. 2004. Effects of bridge shading on estuarine marsh benthic invertebrate community structure and function. Environmental Management 34:99-111.

Stutes, A.L., J. Cebrian and A.A. Corcoran. 2006. Effects of nutrient enrichment and shading on sediment primary production and metabolism in eutrophic estuaries. Marine Ecology Progress Series 312:29-43.

Thompson, J.K., K. Hieb, K. McGourty, N. Cosentino-Manning, S. Wainwright-De La Cruz, M. Elliot, and S. Allen. 2007. Habitat type and associated biological assemblages: soft bottom substrate. In: Schaeffer K., McGourty K., Cosentino-Manning N., editors. Report on the Subtidal Habitats and Associated Biological Taxa in San Francisco Bay. Santa Rosa, CA, US. National Oceanic and Atmospheric Administration, 18-23 (Table 3a), 37-46.

Tuck, I.D., S.J. Hall, and M.R. Robertson. 1998. Effects of physical trawling disturbance in a previously unfished sheltered sheltered Scottish sea loch. Marine Ecology-Progress Series 162:227-242.

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

U.S. Army Corps of Engineers (USACE). 2004. Framework for assessment of potential effects of dredging on sensitive fish species in San Francisco Bay. Final Report. 141 pages. Available at: http://www.spn.usace.army.mil/Portals/68/docs/Dredging/LMTS/S%20and%20S/5%20-%20rpt-USACE-SciencePlan-Final-Aug04-09170.pdf.

U.S. Army Corps of Engineers (USACE), US EPA, WDOE, WDNR, ODEQ, IDEQ, NMFS, and USFWS. 2009. Sediment Evaluation Framework for the Pacific Northwest, prepared by US Army Corps of Engineers – Portland District, Seattle District, Walla Walla District, and Northwestern Division, U.S. Environmental Protection Agency Region 10, Washington Department of Ecology, Washington Department of Natural Resources, Oregon Department of Environmental Quality, Idaho Department of Environmental Quality, National Marine Fisheries Service and U.S. Fish and Wildlife Service. 211 pages. Available at: www.nwp.usace.army.mil/regulatory/docs/SEF/2009-Final_SEF.pdf

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

Van Eenennaam, J.P., J. Linares, S.I. Doroshov, D.C. Hillemeier, T.E. Willson, and A.A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135:151-163.

Watling, L., R.H. Findlay, L.M. Lawrence, and D.F. Schick. 2001. Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community. Journal of Sea Research 46:309-324.