SAN FRANCISCO–OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

INCIDENTAL HARASSMENT AUTHORIZATION APPLICATION

For the Incidental Harassment of Marine Mammals
Resulting from Activities Associated with the
Demolition and Reuse of the Marine Foundations
of the Original East Span of the
San Francisco–Oakland Bay Bridge

EA 04-013584
EFIS#: 04-16000289
04-SF-80 KP 12.2/KP 14.3
04-ALA-80 KP 0.0/KP 2.1

January 2018
Revised March 2018

California Department of Transportation

Caltrans

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The environmental review, consultation, and any other actions required by applicable Federal environmental laws for this project are being, or have been, carried out by Caltrans pursuant to 23 U.S.C. 327 and the Memorandum of Understanding dated December 23, 2016 and executed by FHWA and Caltrans.

Table of Contents

Chapter 1. Description of Specified Activity 1
1.1. Background and Project History 2
1.2. Construction Activities with the Potential to Result in Incidental Take of Marine Mammals 9
Chapter 2. The Dates, Duration, and Specified Geographical Region 17
Chapter 3. Species and Numbers of Marine Mammals 19
Chapter 4. Affected Species Status and Distribution 23
4.1. Pacific Harbor Seal (California Stock) 23
4.2. California Sea Lion (United States Stock) 26
4.3. Northern Elephant Seal (California Breeding Stock) 28
4.4. Northern Fur Seal (California or Eastern Pacific Stock) 29
4.5. Common Bottlenose Dolphin (California Coastal Stock) 30
4.6. Harbor Porpoise (San Francisco–Russian River Stock) 31
4.7. Gray Whale (Eastern North Pacific) 32
4.8. Extralimital or Rare Species 34
Chapter 5. Type of Incidental Taking Authorization Requested 37
5.1. Implosion of Piers E19 and E20 37
5.2. Pile Driving for Construction of OTD Pedestrian Bridge 40
5.3. Levels and Types of Marine Mammal Take 42
Chapter 6. Take Estimates for Marine Mammals 45
6.1. Estimates of Species Densities of Marine Mammals 45
6.2. Implosion of Piers E19 and E20 50
6.3. Pile Driving and Pile Removal Activities 69
6.4. Combined Take Requested for Pier Implosion and Pile-Driving Activities 82
Chapter 7. The Anticipated Impact of the Activity 83
Chapter 8. The Anticipated Impacts on Subsistence Uses 85
Chapter 9. The Anticipated Impacts on Habitat 87
Chapter 10. Anticipated Effects of Habitat Impacts on Marine Mammals 89
Chapter 11. Mitigation Measures 91
11.1. Minimization of Impacts from Implosion of Piers E19 and E20 91
11.2. Minimization of Impacts from Pile Driving 92
Chapter 12. Arctic Plan of Cooperation 95
Chapter 13. Monitoring and Reporting 97
13.1. Monitoring Plan for Implosion of Piers E19 and E20 97
13.2. Monitoring Plan for Pile Driving 101
Chapter 14. Suggested Means of Coordination 107
Chapter 15. List of Preparers 109
Chapter 16. References 111

Appendix A. Piers E3 and E5 Test Blast Hydroacoustic Monitoring Results
Appendix B. Alternatives Analysis

List of Figures

Figure 1. SFOBB New East Span and Original East Span....1
Figure 2. SFOBB Project Location....4
Figure 3. Elevation View of the SFOBB Original East Span....4
Figure 4. SFOBB Original East Span Marine Foundations....6
Figure 5. Pier E2 from the YBI shore and the New SFOBB East Span....7
Figure 6. Location of Pier E2....7
Figure 7. Location of Piers E19 to E23....8
Figure 8. Typical Schematic for Piers E19 through E22....9
Figure 9. BAS Layout Used during the Implosion of Pier E3 in November 2015....12
Figure 10. High-Frequency Cetaceans Pier Implosion Thresholds Distances....52
Figure 11. Mid-Frequency Cetaceans Pier Implosion Thresholds Distances....53
Figure 12. Oteriid Pinniped Pier Implosion Thresholds Distances....54
Figure 13. Phocid Pinniped Pier Implosion Thresholds Distance....55
Figure 14. Marine Mammal Level B Vibratory Pile Driving Thresholds Distances....74
Figure 15. Marine Mammal Level A Impact Pile Driving Thresholds Distances for 36-inch Piles....75

List of Tables

Table 1. Blast Event Removal Dates by Groupings 5
Table 2. Summary of Marine Mammals in San Francisco Bay 20
Table 3. Summary of Marine Mammals with Potential to Occur near Piers E6 to E18 24
Table 4. Underwater Sound Pressure Threshold Criteria for Underwater Blasting 39
Table 5. Underwater Sound Threshold Criteria for Pile Driving 41
Table 6. Estimated In-Water Density of Marine Mammals in the SFOBB Project Area ..... **Error! Bookmark not defined.**
Table 7. Measured Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS from the Previous Implosion of Piers E17 and E18 in a Single Event and Estimated Distances to These Threshold Criteria for the Proposed Implosion of Piers E19 and E20 in a Single Event 56
Table 8. Estimated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Pier E3, Two Small Piers and Four Small Piers 57
Table 9. Level B Behavioral Take Calculations for Implosion of Piers E19 and E20 58
Table 10. Level B TTS Take Calculations for Implosion of Piers E19 and E20 59
Table 11. Level A PTS Take Calculations for Implosion of Piers E19 and E20 59
Table 12. Combined Estimated Exposures of Marine Mammals to the Pier Implosions for Levels A and B, and Mortality Threshold Criteria 60
Table 13. Amount of Level B Harassment Take Requested for the Implosions of Pier E2 and Piers E19 to E22 68
Table 14. Measured Pier E5 Test Blast Sound Levels Compared to Phocid and High-Frequency Cetacean Threshold Criteria 69
Table 15. User Spreadsheet Inputs 71
Table 16. Distances to Levels A and B Harassment Threshold Criteria for Impact and Vibratory Pile Driving and Pile Removal 72
Table 17. Estimated Take of Marine Mammals from Pile Driving and Pile Removal Activities 76
Table 18. Combined Total Take Requested for Pier Implosion and Pile-Driving Activities 82
Table 19. Marine Mammal Level A Exclusion Zones and Level B Monitoring Zones for the Implosion of Piers E19 and E20 98
Table 19. Marine Mammal Level A Exclusion Zones and Level B Monitoring Zones for Pile-Driving Activities 104

List of Abbreviated Terms

µPa	micropascal(s)
BART	Bay Area Rapid Transit
BAS	Blast Attenuation System
Bay	San Francisco Bay
CV	coefficients of variation
dB	decibel(s)
Department	California Department of Transportation
FESA	Federal Endangered Species Act
GI	gastro-intestinal
Hz	hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
MMEZ	marine mammal exclusion zone
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
msec	millisecond(s)
NMFS	National Marine Fisheries Service
OTD	Oakland Touchdown
psi	pounds per square inch
PTS	Permanent Threshold Shift
RMS	root-mean-square
SEL	sound exposure level
SELcum	cumulative sound exposure level
SFOBB Project	San Francisco–Oakland Bay Bridge East Span Seismic Safety Project
SFOBB	San Francisco–Oakland Bay Bridge
SPL	sound pressure level
TMMC	The Marine Mammal Center
TTS	Temporary Threshold Shift
UME	unusual mortality event
YBI	Yerba Buena Island
ZOI	zone of influence

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Chapter 1. Description of Specified Activity

The California Department of Transportation (Department), as part of the San Francisco–Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project (SFOBB Project), has replaced the original east span of the SFOBB with a new bridge north of the former bridge (Figure 1). The SFOBB Project includes both constructing the new east span bridge and dismantling the original east span bridge. Except for five remaining marine foundations (Piers E2, E19-E22), the Department has completed the dismantling of the original east span bridge. The Department is requesting regulatory authorization for the incidental harassment of marine mammals resulting from activities associated with both demolition and reuse of these remaining marine foundations. These activities include: (1) the use of highly controlled charges to dismantle marine foundations, and (2) pile driving associated with the reuse of marine foundations to construct public access improvements.

Source: ESRI 2015 (imagery); compiled by AECOM in 2017

Figure 1. SFOBB New East Span and Original East Span

1.1. Background and Project History

In 2001, in accordance with the Marine Mammal Protection Act (MMPA), the Department requested authorization from the National Marine Fisheries Service (NMFS) for possible harassment of small numbers of two pinniped species (California sea lion and Pacific harbor seal) and one cetacean species (gray whale), incidental to conducting the SFOBB Project. On November 10, 2003, NMFS issued an Incidental Harassment Authorization (IHA) to the Department, authorizing the take of a small number of marine mammals incidental to the SFOBB Project. The Department has been issued 11 subsequent IHAs for the SFOBB Project, in 2005, 2007, 2009, 2011, January and December 2013, 2014, July and September 2015, 2016, and 2017. Harbor porpoise was added to the Department's IHA authorization in 2007. The first five IHAs (2003, 2005, 2007, 2009, and 2011) addressed potential impacts on marine mammals and monitoring requirements associated with pile driving for constructing the new east span. The 2013, 2014, and July 2015 IHAs addressed activities associated with both constructing the new east span and dismantling the original east span—specifically vibratory pile driving, vibratory pile extraction/removal, attenuated impact pile driving, pile proof testing, and mechanical dismantling of temporary and permanent marine foundations. The September 2015 IHA specifically addressed a demonstration project that included use of highly controlled charges to dismantle the Pier E3 marine foundation (the Demonstration Project). Northern elephant seal was added to the Department's IHA authorization in 2015. The 2016 IHA addressed activities associated with dismantling of the original east span—specifically vibratory pile driving, vibratory pile extraction/removal, attenuated impact pile driving, pile proof testing, and the use of highly controlled charges to dismantle the Pier E4 and Pier E5 marine foundations. Northern fur seal and bottlenose dolphin were added to the Department's IHA authorization in 2016. The 2017 IHA addressed the use of highly controlled charges to dismantle the Pier E6 through Pier E18 marine foundations.

Hydroacoustic and marine mammal monitoring has been performed during all activities authorized under the Department's IHAs. Based on the monitoring results, the Department and NMFS determined that in-water mechanical dismantling of marine foundations via drilling, sawing, cutting, cracking, breaking, and pulverizing will not result in the incidental take of marine mammals as defined under the MMPA (Reyff 2015a, Reyff 2015b, S.Guan, pers. comm., 2015). Therefore, the 2016 and 2017 IHAs did not include mechanical dismantling, and the Department is not requesting coverage under this IHA application to conduct these in-water mechanical dismantling activities.

In accordance with the conditions of the September 2015, 2016, and 2017 IHAs, the Department successfully imploded Piers E3 through E18 with highly controlled charges. The successful implosion of the piers, as well as the results from hydroacoustic, biological, and water quality monitoring that were conducted during and following the implosions, demonstrated the use of highly controlled charges to be an effective and efficient method for removal of these types of marine foundations, with the least impact on the environment and biological resources. Hydroacoustic monitoring results from the implosions of Piers E3 through E18 will be used to inform anticipated sound pressure levels (SPLs) and distances to marine mammal threshold criteria for the implosions of Piers E19 through E22.

1.1.1. Project Area

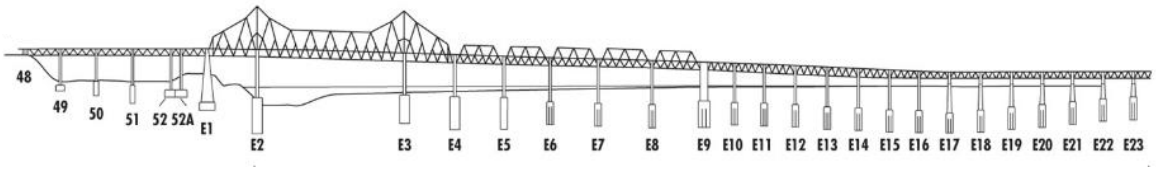
The project area is located in the central part of the San Francisco Bay (the Bay) between Yerba Buena Island (YBI) in the City and County of San Francisco and the City of Oakland in Alameda County (Figures 1 and 2). The western limit of the project area is the east portal of the YBI tunnel. The eastern limit of the project area is located approximately 400 meters (1,300 feet) west of the Bay Bridge toll plaza, where the new spans connect with land at the Oakland Touchdown (OTD) in the City of Oakland. The approximate width of the in-water work area is 350 meters (1,148 feet). This includes all in-water areas under the original bridge and new bridge. All activities proposed under this IHA application will be confined to this area. However, other previous in-water project activities have taken place in discrete areas near both YBI and Treasure Island outside these limits.

Source: ESRI 2015 (imagery); compiled by AECOM in 2017

Figure 2. SFOBB Project Location

1.1.2. SFOBB Original East Span Bridge Marine Foundations

The original east span was supported by 20 in-water bridge piers (Piers E2 to E22), as well as by land-based bridge piers and bents on YBI and in Oakland (Figure 3).



Source: Department 2016

Figure 3. Elevation View of the SFOBB Original East Span

The marine foundations vary in structural type. Pier E2 near the eastern edge of YBI is a large, reinforced concrete, cellular structure, resting on an unreinforced concrete seal course with an average thickness of about 11 meters (35 feet) that bears on rock. Piers E3, E4, and E5 were founded on concrete caissons that were advanced over 40 meters (130 feet) into the soil beneath the waters of the Bay. Piers E6 to E22 consist of lightly reinforced concrete foundations, supported by timber piles driven into the Bay mud. Pier

E23 is located in the intertidal zone and consists of a lightly reinforced concrete foundation, supported by timber piles into the Bay's shore.

1.1.3. Dismantling the Original East Span

Dismantling the SFOBB original east span began in late 2013, after the new bridge was opened to traffic. Dismantling of the bridge superstructure (i.e., elevated steel members) was completed in April 2017. Ongoing work on YBI includes restoring and improving the project site and adjacent United States Coast Guard station. Marine foundation removal began with the dismantling of Pier E3, begun in April 2015. Controlled blasting was used to implode the in-water portion of Pier E3 on November 14, 2015. All debris resulting from the controlled blast was removed to below mudline, and the cleanup was completed in December 2015. Pier E3 was the first marine foundation chosen for dismantling; it was selected to demonstrate the effective use of controlled blasting to remove the marine foundation. The next phase of marine foundation removal incorporated the experience from the Pier E3 Demonstration Project. Mechanical dismantling of Piers E4 to E18 began in March 2016. Implosion of Piers E4 and E5 was completed in October 2016. Implosion of Piers E6 to E18 was completed in fall 2017. The removal of debris resulting from the controlled blasting was completed as of November 2017.

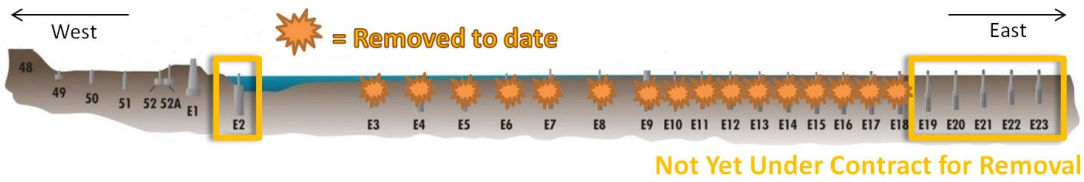
Piers E3 to E18 were removed during nine separate blast events. These blast events included single or multiple piers being removed within the event. Blast events that included multiple piers were sequenced with approximately a quarter of a second between each pier blast. Table 1 summarizes the dates and groupings of blast events that have occurred to date.

Table 1. Blast Event Removal Dates by Groupings

Pier Grouping	Removal Date
Pier E3	November 14, 2015
Pier E4	October 29, 2016
Pier E5	October 15, 2017
Pier E6	September 16, 2017
Pier E7 and Pier E8	September 2, 2017
Pier E9 and Pier E10	September 30, 2017
Pier E11, Pier E12 and Pier E13	October 14, 2017
Pier E14, Pier E15 and Pier E16	October 28, 2017
Pier E17 and Pier E18	November 11, 2017

Source: Compiled by AECOM 2017

The remaining marine foundations consist of Pier E2 near the YBI shoreline and Piers E19 through E22 near the Oakland shoreline (Figure 4). Pier E23 is located on land at the Oakland shoreline.



Source: ESRI 2015 (imagery); compiled by AECOM in 2017

Figure 4. SFOBB Original East Span Marine Foundations

1.1.4. Description of Remaining Piers

Pier E2 Description

Pier E2 at the eastern edge of YBI is a large, reinforced concrete, cellular structure, resting on an unreinforced concrete seal course with an average thickness of about 11 meters (35 feet) that bears on rock. The dimensions of the seal course are approximately 37 by 13 meters (122 by 43 feet), and the cellular structure of the pier is 37 by 12 meters (121 by 41 feet). The reinforced concrete walls within Pier E2 range from 0.91 to 1.21 meters (3 to 4 feet) in thickness. The current condition of Pier E2 in the San Francisco Bay is shown in Figure 5, and location shown in Figure 6. The hollow chambers of Pier E2 contain water. Weep holes in the foundation allow water inside the caisson to exchange with the Bay water, and this varies in height with the tide.

Source: Department 2017

Figure 5. Pier E2 from the YBI shore and the New SFOBB East Span

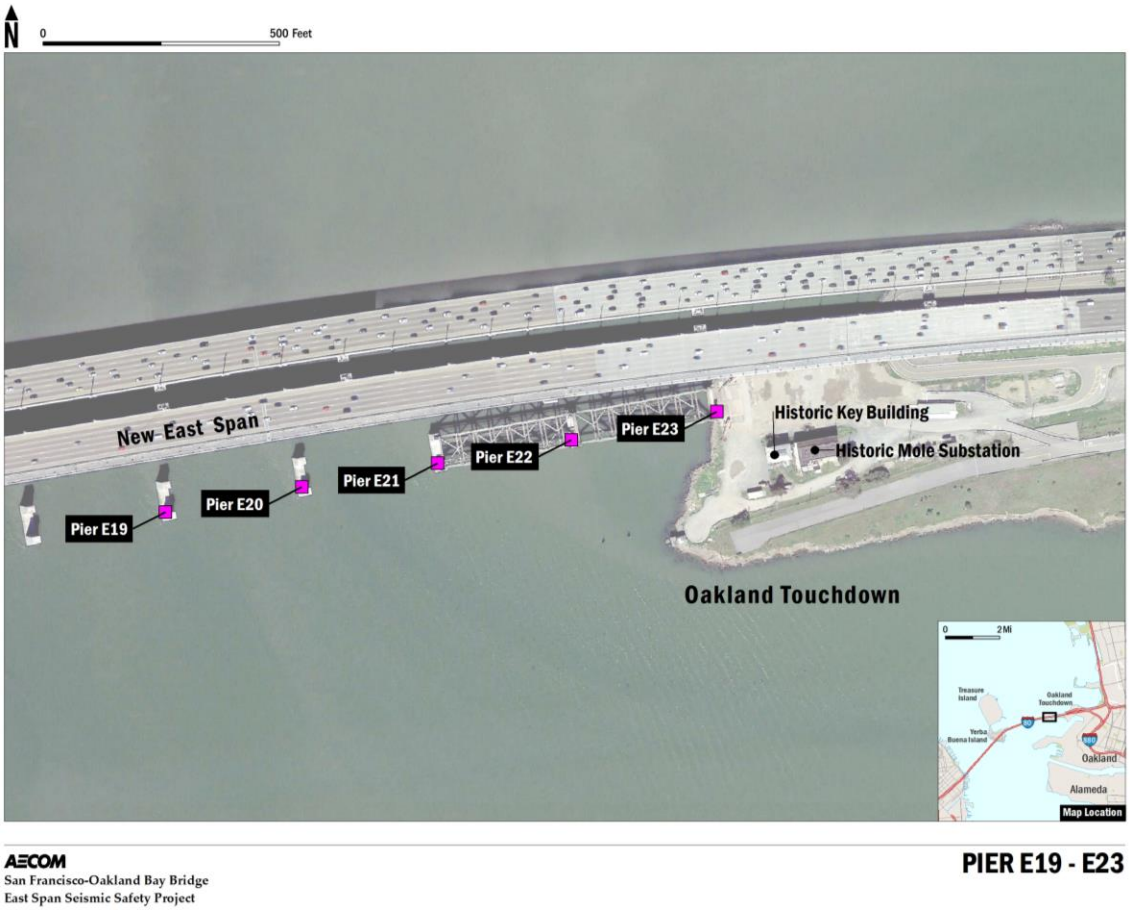
Source: ESRI 2015 (imagery); compiled by AECOM in 2017

Figure 6. Location of Pier E2

Piers E19 to E22 Descriptions

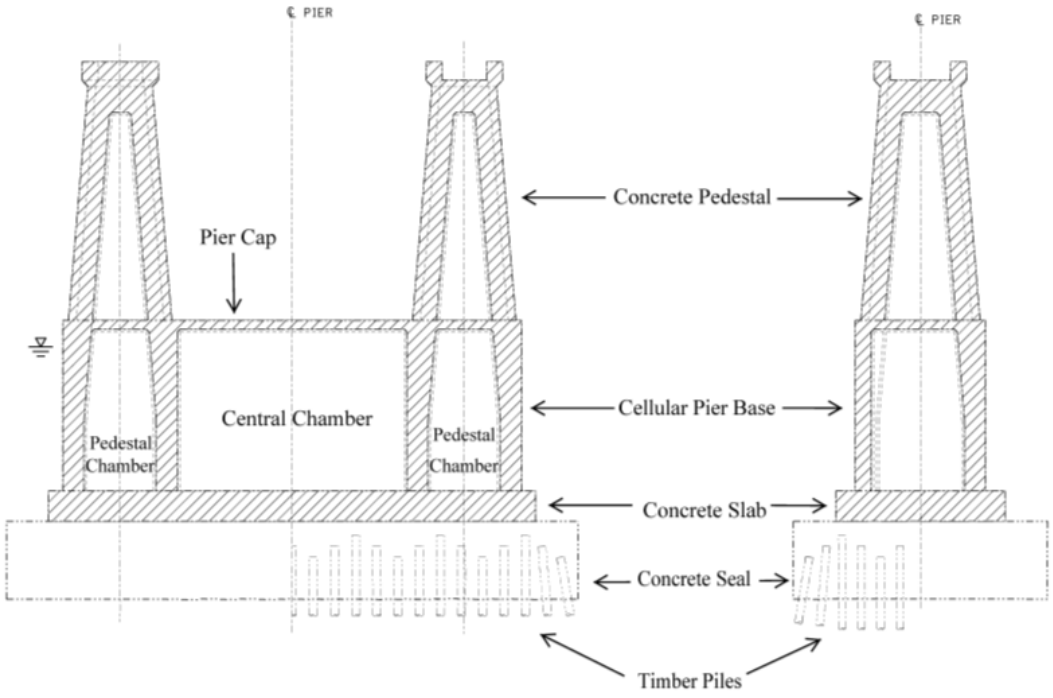
Piers E19 to E22 were constructed to support the steel superstructure of the SFOBB original east span. The piers are cellular concrete structures. None of the piers reaches down to bedrock.

Piers E19 to E22 are each supported by timber piles (all piles are untreated Douglas fir). A concrete seal was poured on top of each pile set. Concrete seals were poured well below the surrounding mudline elevation, approximately 3 to 6 meters (10 to 20 feet) up to the mudline elevation during construction. On top of the concrete seals, a flat, unreinforced concrete slab was poured to support the cast-in-place concrete piers. The locations of Piers E19 to E23 are shown in Figure 7, and a typical schematic of Piers E19 through E22 is shown in Figure 8. Pier E23 showing in Figure 7 is located on land at the Oakland shoreline.



Source: Department 2017 (imagery); compiled by AECOM in 2017

Figure 7. Location of Piers E19 to E23



Source: Department 2016 (imagery); compiled by AECOM in 2016

Figure 8. Typical Schematic for Piers E19 through E22

1.2. Construction Activities with the Potential to Result in Incidental Take of Marine Mammals

Construction activities associated with both dismantling and reuse of marine foundations of the original east span bridge may result in the incidental take of marine mammals. These activities include the use of highly controlled charges to dismantle Pier Piers E19 and E20, as well as pile-driving activities associated with construction of a public access facility that will incorporate reuse Piers E21, E22 and E23. Pier E2 will also be retained and incorporated into a public access facility. However, public access improvements at Pier E2 will not require any in-water work and would not result in incidental take of marine mammals; therefore, are not discussed further.

1.2.1. Removal of Piers E19 and E20

The removal of Piers E19 and E20 will be performed in three phases. The first phase will use mechanical dismantling to remove the above-water portions of the piers. The second phase will use controlled blasting methods for removal of the in-water portions of the piers. The third phase will include dredging of imploded rubble to specified removal

limits. Limits of removal will be determined at each location and will result in removal to between 0.46 and 0.91 meter (1.5 and 3 feet) below the mudline.

Piers E19 and E20 are large cellular structures through the water column, which are supported on concrete slabs and hundreds of driven timber piles encased in a concrete seal. The timber piles and concrete seal courses that are below approved removal limits will remain in place. Rubble that mounds above the determined debris removal elevation limits from the dismantling of these piers will be removed off-site for disposal; as was done during the removal of Piers E6 to E18.

A Blast Attenuation System (BAS) similar to that used for previous blast events will be used during all future controlled blasting events, to minimize potential impacts on biological resources in the Bay. The effectiveness of this minimization measure is supported by the findings from the successful removal of Piers E3 to E18. As demonstrated, controlled blasting is the most expeditious marine foundation removal method, having the least adverse effects on marine resources compared to mechanical removal methods within a de-watered cofferdam.

Each pier will be removed in the following three phases:

- pre-blast activities, including removing the pier cap and concrete pedestals, installing and testing the BAS;
- installing charges, activating the BAS, and imploding the pier; and
- dredging of imploded rubble to specified removal limits.

Steps to remove the marine foundations will include: Phase 1: dismantling the concrete pedestals and concrete pier cap by mechanical means (including the use of torches and excavators mounted with hoe rams, drills, and cutting tools), and drilling vertical boreholes where the charges will be loaded for controlled blasting. Phase 2: The charges then will be loaded into the drilled boreholes. Controlled blasting removal will be accomplished using hundreds of small charges, with delays between individual charges. The controlled blast sequence for each pier will last approximately 1 to 5 seconds. The controlled blast removals have been designed to remove each pier to between 0.46 and 0.91 meter (1.5 and 3 feet) below the mudline. Phase 3: Dredging of imploded rubble to specified removal limits.

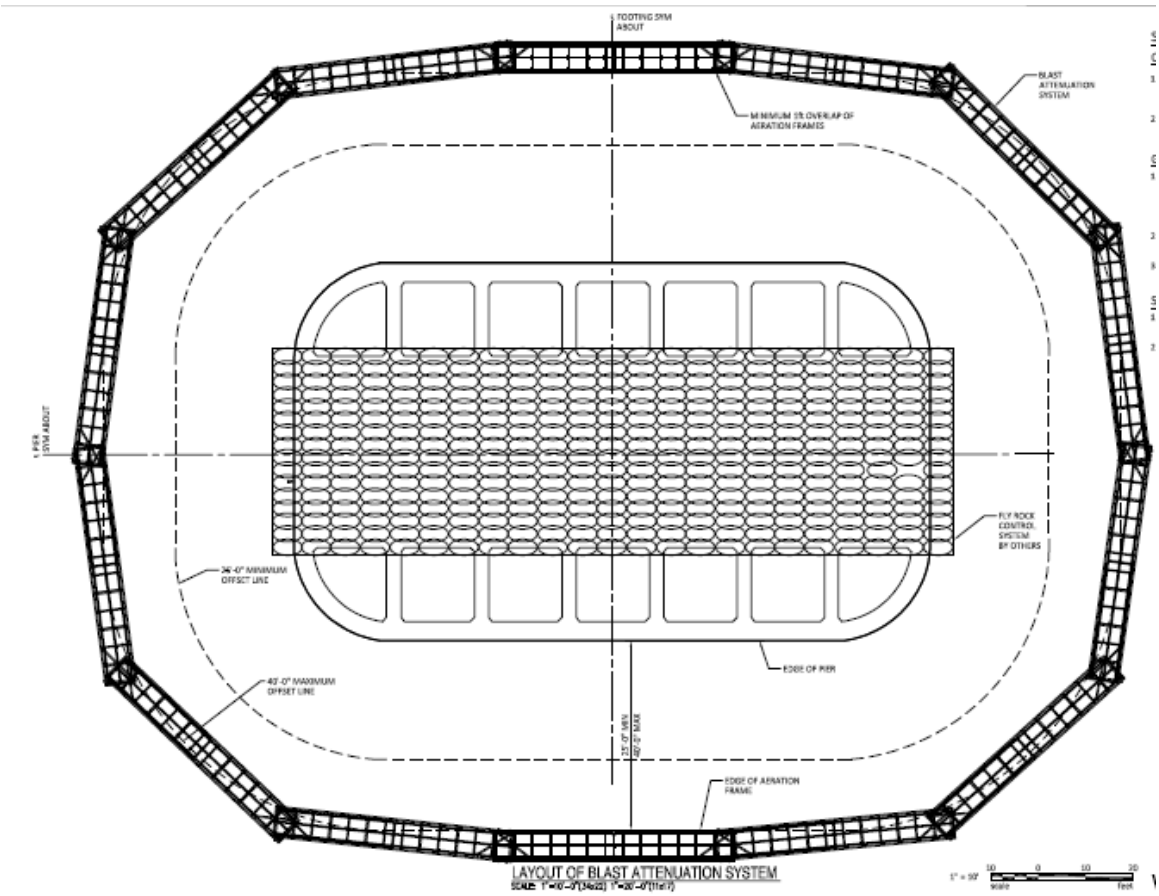
Blast Attenuation System Testing, Installation, and Deployment

The BAS will be deployed around each pier being imploded and will be a similar system to that successfully used for the removal of Piers E3 to E18. The BAS is a modular

system of pipe manifold frames, placed around each pier and fed by air compressors to create a curtain of air bubbles. Each BAS frame is approximately 15.4 meters long by 1.8 meters wide (50.5 feet long by 6 feet wide). The BAS to be used will be the same design that was used at Piers E3 to E18 and will meet the same specifications. The BAS will be activated before and during implosion. As shown during the Pier E3 Demonstration Project and eight subsequent pier blast events by the SFOBB Project, the BAS will attenuate noise and pressure waves generated during each controlled blast, to minimize potentially adverse effects on biological resources that may be nearby.

Before installing the BAS, the Department will move any existing debris on the Bay floor that may interrupt or conflict with proper installation of the BAS. Each BAS frame will be lowered to the bottom of the Bay by a barge-mounted crane and will be positioned into place. Divers will assist frame placement and will the connect air hoses to the frames. Based on location around the pier, the BAS frame elements will be situated from approximately 8 to 12 meters (25 to 40 feet) from the outside edge of each pier. The frames will be situated to contiguously surround each pier. Frame ends will overlap to ensure no break in the BAS when operational. Each frame will be weighted to negative buoyancy for activation. Compressors will provide enough pressure to achieve a minimal air volume fraction of 3 to 4 percent, consistent with the successful use of BAS systems in past controlled blasting activities. The BAS layout that was used during the implosion of Pier E3 is shown in Figure 9.

The complete BAS will be installed and tested during the weeks leading up to the controlled blast. The BAS test parameters will include checking operating levels, flow rate, and a visual check to determine that the system is operating correctly. System performance is anticipated to provide approximately 80 percent noise and pressure



Source: Kiewit 2015

Figure 9. BAS Layout Used during the Implosion of Pier E3 in November 2015

attenuation, based on the results from the previous SFOBB Project blast events using a similar system.

Test Blasts

Test blasts may be conducted to ensure that the hydroacoustic monitoring equipment will be functional and triggered properly before the pier implosion event. The test blasts would be conducted within the completely installed and operating BAS. A key requirement of pier implosion will involve accurately capturing hydroacoustic information from the controlled blast. To accomplish this, a smaller test charge will be used to trigger recording instrumentation. Multiple test blasts on the same day may be required to verify proper instrument operation and calibrate the equipment for the implosion events. These same instruments and others of the same type will use high-speed recording devices to capture hydroacoustic data at both near-field and far-field monitoring locations during the implosion.

Test blasts will be scheduled to occur within 2 weeks of the scheduled implosion. Tests will use a charge weight of approximately 18 grains (0.0025 pound) or less and will be placed along one of the longer faces of the pier. The results from test blasts that occurred before the implosions of Pier E3 and E5 indicate that these test blasts will have minimal impacts on fish and no impacts on marine mammals (see Appendix A).

Controlled Blasting of Remaining Pier Structures

Piers E19 and E20 will be imploded during a single event. Before pier removal via controlled blasting, the Department will load the bore holes of the pier with controlled charges. Individual cartridge charges using electronic blasting caps have been selected to provide greater control and accuracy in determining the individual and total charge weights. Use of individual cartridges will allow a refined blast plan that efficiently breaks concrete while minimizing the amount of charges needed.

Boreholes will vary in diameter and depth, and have been designed to provide optimal efficiency in transferring the energy created by the controlled charges to dismantle the piers. Individual charge weights will vary from 7 to 11 kilograms (15 to 25 pounds), and the total charge weight for the Pier E19 and E20 blast event will be approximately 1,800 kilograms (4,000 pounds). The total number of individual charges to be used per pier will be approximately 100. Charges will be arranged in different levels (decks) and will be separated in the boreholes by stemming. Stemming is the insertion of inert materials (e.g., sand or gravel) to insulate and retain charges in an enclosed space. Stemming allows more efficient transfer of energy into the structural concrete for fracture, and further reduces the release of potential energy into the surrounding water column. The entire detonation sequence, consisting of approximately 200 detonations, will last approximately 1 to 5 seconds for each pier; with a minimum delay time of 9 milliseconds (msec) between detonations. There will be approximately half a second delay between pier blasts to avoid overlap of pressure waves.

Piers E19 and E20 will be blasted in a single pier implosion event. These piers will be removed by blasting down through the concrete cellular structure but not through the concrete slab, seal, and timber piles below. Remaining concrete seals and timber piles below the mudline will not be removed.

Controlled implosion of piers may result in the incidental harassment of marine mammals.

Public Safety

Public safety measures will be implemented continuously during the controlled blast. Safety zones will be established and enforced to exclude any marine traffic that is not directly involved in the controlled blast. Marine traffic and recreational boating activities will be restricted, excluding them from a radius of 457 meters (1,500 feet) around each pier because of the safety concerns inherent with the use of explosives. Safety procedures on the new east span bridge may include implementing roadway traffic management in both directions and complete closure of public access to the bike path/pedestrian walkway in advance of each controlled implosion.

Debris Removal and Site Restoration

Following the controlled blasting event and confirmation that the area is safe for work, construction crews will remove all associated equipment, including barges, compressors, the BAS, and blast mats.

Any portion of a structure that may remain above the removal limits after blasting is completed will be demolished by mechanical means. This may require use of underwater mechanical equipment, including hydraulic crushing or grinding machinery, or diver-operated jackhammers.

Rubble resulting from the controlled blasting of Piers E19 and E20 will be removed down to each pier's respective planned debris removal limit elevation by a barge-mounted crane with a clamming bucket. The clamming bucket will be equipped with a GPS unit, to accurately guide the movement of the bucket during underwater operation.

Debris removal and site restoration activates will not result in take or harassment of marine mammals and are not discussed further.

Schedule/Duration

Through analysis and agency consultation, the Department has determined that to minimize potential impacts on biological resources in the Bay, the ideal time of year to conduct the controlled blast is September to November. Therefore, the Department proposes to conduct pier removal by controlled blasting during those months. The cleanup and in-water site management operations, as described above, are expected to take some additional weeks following the controlled blast and to be completed by the middle of December.

1.2.2. Reuse of Piers E21 to E23 for Public Access

A pedestrian bridge and observation platforms, will be constructed near the Oakland shoreline, using the existing marine foundations as anchors for this public access facility. Construction of this facility at Piers E21 to E23 (Oakland side) will require mechanical removal of some or perhaps all of the pedestals and pier slabs to elevations required by the design. Both temporary and permanent piles will be needed for construction of this pedestrian bridge and observation platforms.

OTD Pedestrian Bridge and Observation Areas

The OTD pedestrian bridge will extend from Pier E23 on the Oakland shoreline to Pier E21. It will be supported by Piers E23, E22, and E21. Observation areas also may be constructed at Piers E22 and E21. Reinforced concrete slabs may be constructed on top of Piers E22 and E21, to serve as an observation platforms. The existing pier foundations are spaced 88 meters (290 feet) apart. New intermediate piers will be constructed between the existing pier foundations to support the pedestrian bridge. These permanent intermediate piers will be pile-supported.

A temporary access trestle also may also be needed to facilitate construction of the pedestrian bridge. This temporary access trestle will be pile-supported.

Both the pedestrian bridge and temporary access trestle will be designed by the construction contractor. Because these structures will be contractor-designed, their exact nature (e.g., size, type, number of piles) will not be known until construction begins. However, the Department has developed a conservative estimate as to the approximate type, size, and number of piles needed for these proposed structures. Up to 200 in-water piles may be required for construction of the OTD pedestrian bridge and temporary access trestle. These piles may be concrete piles, steel pipe piles, or H-piles. The concrete piles or steel pipe piles will be 24 to 36 inches in diameter, or less.

In-water pile driving for construction of the pedestrian bridge and temporary access trestle may result in the incidental harassment of marine mammals.

Schedule/Duration

The Department plans to begin pile driving for construction of these facilities in June 2018. Construction of these facilities will be completed by December 31, 2018. In-water pile driving will be restricted from June 1 to November 30, to avoid peak salmonid migration periods.

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Chapter 2. The Dates, Duration, and Specified Geographical Region

Construction activities for replacement of the SFOBB original east span started in 2002. The new east span opened to traffic in September 2013. Construction activities for dismantling the original east span started in 2013 and are ongoing. The current IHA, which covers implosion of Piers E6 to E18, was authorized from September 1, 2017, and will expire on August 31, 2018.

The Department is requesting issuance of a new IHA for a 1-year period. Vibratory pile driving for construction of the OTD pedestrian bridge and OTD access trestle may begin in June 2018. Impact pile-driving activities will be restricted from June 1 to November 30, to avoid peak salmonid migration periods. Pier implosion requiring IHA coverage is scheduled to begin in September 2018. Pier implosion will be restricted from September 1 to November 30, to minimize potential impacts on biological resources in the Bay. To allow sufficient time to prepare a biological monitoring plan and coordinate resources and staff to meet the final conditions of the IHA, the Department is requesting issuance of this new IHA no later than mid-May, 2018.

Pile-driving activities will take place between and adjacent to Piers E21, E22, and E23, near the OTD (Figure 8). Pier implosion will take place at Piers E19 and E20 near the OTD (Figure 4).

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Chapter 3. Species and Numbers of Marine Mammals

Seven species of marine mammals regularly inhabit or seasonally enter the Bay (Table 2). The two most common species observed are the Pacific harbor seal (*Phoca vitulina richardii*) and the California sea lion (*Zalophus californianus*). Harbor porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncatus*) enter the Bay throughout the year. Harbor porpoise mainly has been observed near the Golden Gate, near Marin County and the city of San Francisco on the northwestern side of the Bay, and only rarely has been observed near the SFOBB east span, on the eastern side of the Bay. However, during recent monitoring performed in 2017, a pod of three to four harbor porpoises was observed regularly near the SFOBB east span. Bottlenose dolphin is a recent visitor to the Bay and is present only in small numbers. Juvenile northern elephant seal (*Mirounga angustirostris*) seasonally enters the Bay in spring and fall (December to March), and juvenile northern fur seal (*Callorhinus ursinus*) seasonally enters the Bay in fall and spring (May to October). Gray whale (*Eschrichtius robustus*) may enter the Bay during its northward migration in the late winter and spring, but is unlikely to occur near the project area during September, October, and November, when the pier implosions will take place. None of these species are listed as endangered or threatened under the Federal Endangered Species Act (FESA), or as a depleted or a strategic stock under the MMPA. In addition to the seven common or regularly occurring species, seven species of marine mammals are considered extralimital (rare sightings or strandings in the Bay) and are unlikely to occur in the Bay (Table 2).

Information on the seasonal occurrence and estimated densities of harbor seals, sea lions, and harbor porpoises in the vicinity of the SFOBB original east span were estimated from marine mammal monitoring, conducted intermittently from 2000 to 2016, during the pile installation demonstration project, pile driving of permanent and temporary piles for new bridge construction, demolition of temporary tower foundations, blasting on YBI for Towers W2E and W2W, and the mechanical and the controlled implosions of Pier E3, E4, and E5. The amount of monitoring performed per year varied, depending on the frequency and duration of construction activities with the potential to affect marine mammals. During 251 days of monitoring (including 15 days of baseline monitoring in 2003), 958 harbor seals, 80 California sea lions, and nine harbor porpoises were observed in the vicinity of the SFOBB east span (Department 2001, 2004b, 2013b, 2013c, 2014, 2015b, 2016, 2017).

Table 2. Summary of Marine Mammals in San Francisco Bay

Species	Stock	Status (FESA and MMPA)	Population	Population Trend
Species with Regular or Seasonally Occurrence in the San Francisco Bay				
Phocids				
Pacific Harbor Seal *Phoca vitulina richardii*	California	Not Listed	30,968 (CV=0.157)	Decreasing
Northern Elephant Seal *Mirounga angustirostris*	California Breeding	Not Listed	179,000	Increasing
Otariids				
California Sea Lion *Zalophus californianus*	United States	Not Listed	296,750	Increasing
Northern Fur Seal *Callorhinus ursinus*	California Eastern North Pacific	Not Listed Not Listed	14,050 626,734	Increasing Decreasing
Odontocetes				
Harbor Porpoise *Phocoena phocoena*	San Francisco-Russian River	Not Listed	9,886 (CV=0.51)	Stable
Common Bottlenose Dolphin *Tursiops truncatus*	California Coastal	Not Listed	453 (CV=0.06)	Increasing
Mysticetes				
Gray Whale *Eschrichtius robustus*	Eastern North Pacific	Not Listed	20,990 (CV=0.05)	Stable
Species that are Extralimital to the San Francisco Bay				
Sea Otter *Enhydra lutris*	Southern (California population)	Threatened (ESA) Strategic (MMPA) Depleted (MMPA)	3,272	Increasing
Steller Sea Lion *Eumetopias jubatus*	Eastern (California Haul-out Sites)	Threatened (ESA) Strategic (MMPA) Depleted (MMPA)	4,056	Increasing (Stable in California)
Short-Beaked Common Dolphin *Delphinus delphis delphis*	California/Oregon/Washington	Not Listed	969,861 (CV= 0.17)	Increasing
Fin Whale *Balaenoptera physalus physalus*	California/Oregon/Washington	Endangered (ESA) Strategic (MMPA) Depleted (MMPA)	9,029 (CV=0.12)	Stable
Humpback Whale *Megaptera novaeangliae*	California/Oregon/Washington	Endangered (ESA) Strategic (MMPA) Depleted (MMPA)	1,918 (CV=0.03)	Increasing
Minke Whale *Balaenoptera acutorostrata scammoni*	California/Oregon/Washington	Not Listed	636 (CV=0.72)	Unknown
Sperm Whale *Physeter macrocephalus*	California/Oregon/Washington	Endangered (ESA) Strategic (MMPA) Depleted (MMPA)	2,106 (CV=0.58)	Unknown

Notes:
CV = Coefficients of Variation; FESA = Federal Endangered Species Act; MMPA = Marine Mammal Protection Act
Sources: Carretta et al. 2016; Allen and Angliss 2014

During this entire time, only two individuals showed responses to pile driving noise. In 2000, a sea lion was swimming slowly at the surface, approximately 1,000 meters (3,281 feet) west of a pile-driving site. This individual then rapidly swam north at the start of pile driving (Thorson and Wagner 2001). In 2004, a harbor seal swam toward the pile-driving barge during pile driving for the eastbound Skyway, and at approximately 55 meters (180 feet) from the piles, it abruptly turned around and dove (Department 2004b). Otherwise, most seals or sea lions were observed at least 100 meters (328 feet) beyond the pile-driving activities. When an animal transited through the area, it typically looked toward the piles but did not change swimming speed or direction (Thorson and Wagner 2001; Department 2004b).

During past monitoring, the number of harbor seals that were observed increased as construction or demolition activities moved closer to YBI. Coast Guard Cove and Clipper Cove (between YBI and Treasure Island), and a small trench area 300 meters (984 feet) southeast of YBI are used frequently by harbor seals to forage. In 2015, juvenile harbor seals began foraging around Pier E2 of the new SFOBB east span and expanded to Piers E3 and E4 in 2016 (Department 2017). Algae and invertebrate growth on the piers of the new bridge likely has attracted fish, which the young seals easily can catch. YBI also is the site of one of the main harbor seal haul-outs in the Bay (Figure 11) (Department 2004b).

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Chapter 4. Affected Species Status and Distribution

Seven species may be affected by the SFOBB Project. The following discussion outlines their distribution and current population status. A summary of the information in this chapter is shown in Table 3.

4.1. Pacific Harbor Seal (California Stock)

Status: The harbor seal is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA. The California stock of harbor seals increased from 1972 through 2004, but showed a decline from 2009 through 2012 (Carretta et al 2017). The population for the California stock during the last count in 2012 was estimated at 30,968 seals (coefficients of variation [CV]=0.157; Carretta et al. 2017).

Distribution: Harbor seals are found from Baja California to the eastern Aleutian Islands of Alaska. The species primarily hauls out on remote mainland and island beaches and reefs, and estuary areas. Harbor seal tends to forage locally within 53 miles (85 kilometers) of haul-out sites (Harvey and Goley 2011). Harbor seal is the most common marine mammal species observed in the Bay and also commonly is seen near the SFOBB east span (Department 2013b, 2013c). Tagging studies have shown that most seals tagged in the Bay remain in the Bay (Harvey and Goley 2011; Manugian 2013). Foraging often occurs in the Bay, as noted by observations of seals exhibiting foraging behavior (short dives less than 5 minutes, moving back and forth in an area, and sometimes tearing up prey at the surface).

The molt occurs from May through June. During both pupping and molt seasons, the number of seals and the length of time hauled out per day increases, with about 60.5 percent of the population hauled out during this time versus less than 20 percent in fall (Yochem et al. 1987; Huber et al. 2001; Harvey and Goley 2011). Mother-pup pairs spend more time on shore; therefore, the percentage of seals on shore at haul-out sites increases during the pupping season (Stewart and Yochem 1994). Peak numbers of harbor seals hauling out in central California occurs during late May to early June, which coincides with the peak of their molt. Seals haul out more often and spend more time on shore to molt. Yochem et al. (1987) found that harbor seals at San Miguel Island only hauled out 11 to 19 percent of the time in fall, from late October through early December.

Table 3. Summary of Marine Mammals with Potential to Occur near Piers E6 to E18

Species	Population in SF Bay	Distribution in SF Bay	Seasons Present In SF Bay	Pupping/Calving Season	Dive Duration	Audiogram (Maximum Sensitivity)	Group Or Pod Size	Haul-Out Sites (Distance to Pier E4)
Pacific Harbor Seal	Up to 2,000	Throughout the Bay	All Seasons	March–June (in the Bay)	3 to 10 minutes (maximum of 30 minutes)	1–60 kHz (32 kHz)	1	YBI (4,593 feet; 1,400 meters)
California Sea Lion	Up to 2,000	Throughout the Bay	All Seasons, more in Summer to Winter	May–July (not in the Bay)	3-7 minutes (maximum of 10 minutes)	1–40 kHz (2–16 kHz)	1	Pier 39 (3.3 miles; 5.7 kilometers)
Northern Elephant Seal	Up to 100 (stranded juveniles)	Throughout the Bay	Spring to Fall	December–March	10-15 minutes (maximum of 45 minutes)	3.2–55 kHz (3.2–45 kHz)	1	Mostly stranded, rare haul out on YBI and TI
Northern Fur Seal	Rare	May strand at YBI or Treasure Island (TI)	Fall to Spring	May–October	3-7 minutes (maximum of 10 minutes)	1–40 kHz (2–16 kHz)	1	Mostly stranded, some haul out on YBI and TI
Common Bottlenose Dolphin	Occasional	Mostly the Western Bay	Summer to Fall	All year	Up to 15 minutes	1–165 kHz (25–70 kHz)	Up to 12	N/A
Harbor Porpoise	Up to 200	The Western and Northern Bay	All Seasons	Spring (not in the Bay)	Short dives up to 5 minutes	8–140 kHz (16–140 kHz)	Up to 6	N/A
Gray Whale	Up to 6 per year	Throughout the Bay	Late Winter to Spring	Winter (not in the Bay	Short dives	100 Hz–4 kHz	1–2	N/A

Source: see species description in Sections 4.1–4.7

Harbor seal tends to forage at night and haul out during the day. Harbor seal predominately hauls out from 10 a.m. to 7 p.m., with a peak in the afternoon between 1 and 4 p.m. (Yochem et al. 1987; Stewart and Yochem 1994; Grigg et al. 2002; London et al. 2012). Harbor seals in the Bay typically haul out in groups ranging from a few individuals to several hundred seals. One known haul-out site is on the southern side of YBI, approximately 1,600 meters (5,250 feet) from Pier E6 and approximately 2,800 meters (9,190 feet) from Pier E18. The YBI haul-out site had a daily range of zero to 109 harbor seals hauled out during September, October, and November, with the highest numbers hauled out during afternoon low tides (Department 2004b). Pile driving for the SFOBB was not audible to the monitors just above the haul-out site, and no response to pile driving was observed.

Tide level also can affect haul-out behavior, by exposing and submerging preferred haul-out sites. Tides likely affect the maximum number of seals hauled out, but time of day and the season have the greatest influence on haul-out behavior (Stewart and Yochem 1994; Patterson and Acevedo-Gutiérrez 2008).

SFOBB Project Area: Harbor seals in the Bay are an isolated population, although about 40 percent may move a short distance out of the Bay to forage (Manugian et al. 2017). The Bay harbor seals likely are accustomed to a noisy environment because of construction, vessel traffic, the Bay Area Rapid Transit (BART) Transbay Tube, and mechanical noise (i.e., machinery, generators).

During 251 days of SFOBB monitoring, 958 harbor seals were observed in the vicinity of the SFOBB east span. Harbor seals made up 90 percent of the marine mammals observed during monitoring for the SFOBB Project. In 2015 and 2016, the number of harbor seals sighted in the project area increased (8 days of monitoring and 95 sightings). Foraging near the project area was common, particularly in the coves adjacent to the YBI United States Coast Guard Station and in Clipper Cove between YBI and Treasure Island. Foraging also occurred in a shallow trench area southeast of YBI (Department 2013a, 2013b). These sites are more than 900 to 1,525 meters (3,000 to 5,000 feet) west of Pier E6. In 2015, juvenile harbor seals began foraging around Piers E2W and E2E of the new SFOBB east span, and in 2016, they extended east around Piers E3 to E5 of the new SFOBB east span. Foraging can occur throughout the Bay, and prey abundance and distribution affect where harbor seals will forage. Most of the harbor seal sightings were animals transiting the area, likely moving from haul-out sites or from foraging areas.

Reproduction and Breeding: Pupping begins in late March in central California and pups start weaning in May. All pups are weaned by mid-June. Breeding occurs between late March and early May.

Diving and Foraging: Harbor seals generally are shallow divers, with about 90 percent of dives lasting less than 7 minutes (Gjertz et al. 1991; Eguchi and Harvey 2005), and with a maximum recorded dive time of 32 minutes (Eguchi and Harvey 2005).

Acoustics: Adult males produce low-frequency vocalizations underwater during the breeding season (Hanggi and Schusterman 1994; Van Parijs et al. 2003). Male harbor seals produce sounds in the frequency range of 100 to 1,000 hertz (Hz) (Richardson et al. 1995). Generally, harbor seals do not vocalize while traveling or feeding; therefore, attempts to acoustically detect them before underwater implosions will not be useful. Harbor seals hear at frequencies from 1 to 180 kilohertz (kHz) (Møhl 1968); however, the species' hearing is most acute below 60 kHz, with peak hearing sensitivity at 32 kHz in water and 12 kHz in air (Terhune 1968; Terhune and Turnball 1995; Kastak and Schusterman 1998; Wolski et al. 2003).

4.2. California Sea Lion (United States Stock)

Status: The California sea lion is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA. The United States stock increased from 1975 through 2008, with an estimated population of 296,750 sea lions (Carretta et al. 2017). Exceptions to the increasing population trend have been observed after El Nino events, domoic acid poisoning, and an unusual mortality event (UME) declared by NMFS in 2013.

Distribution: California sea lion breeds on the offshore islands of California from May through July (Heath and Perrin 2008). During the non-breeding season, adult and sub-adult males and juveniles migrate northward along the coast, to central and northern California, Oregon, Washington, and Vancouver Island (Jefferson et al. 1993). They return south the following spring (Lowry and Forney 2005; Heath and Perrin 2008). Females and some juveniles tend to remain closer to rookeries (Antonelis et al. 1990; Melin et al. 2008).

California sea lions have been observed occupying docks near Pier 39 in San Francisco, about 3.2 miles (5.2 kilometers) from the project area, since 1987. The highest number of

sea lions recorded at Pier 39 was 1,701 individuals in November 2009 (De Rango, pers. comm., 2013). Occurrence of sea lions here typically is lowest in June (breeding season) and highest in August. Approximately 85 percent of the animals that haul out at this site are males, and no pupping has been observed here or at any other site in the Bay (Lander, pers. comm., 1999). Pier 39 is the only regularly used haul-out site in the project vicinity, but sea lions occasionally haul out on human-made structures, such as bridge piers, jetties, or navigation buoys (Riedman 1990).

SFOBB Project Area: During monitoring for the SFOBB Project, 80 California sea lions were observed from 2000 through 2016. The number of sea lions that were sighted in the project area decreased in 2015 and 2016. Sea lions appear mainly to be transiting through the project area rather than feeding, although two exceptions have occurred. In 2004, several sea lions were observed following a school of Pacific herring that moved through the project area, and one sea lion was observed eating a large fish in 2015.

Reproduction and Breeding: Breeding and pupping occur from mid to late May until late July. After the mating season, adult males migrate northward to feeding areas as far away as the Gulf of Alaska (Lowry et al. 1992), and they remain away until spring (March–May), when they migrate back to the breeding colonies. Adult females remain near the rookeries throughout the year and alternate between foraging and nursing their pups on shore until the next pupping/breeding season.

Diving and Foraging: Over one-third of the foraging dives by lactating females are 1 to 2 minutes in duration, and 75 percent of dives are less than 3 minutes long, with the longest recorded dive being 9.9 minutes (Feldkamp et al. 1989). More recent studies of adult lactating females have reported a range of mean dive durations from 1.6 to 8.1 minutes (Melin et al. 2008). Most sea lions in the Bay are juveniles or sub-adult males, and are similar in size to adult lactating female sea lions; therefore, these dive data should approximate the diving abilities of the Bay sea lions.

Acoustics: California sea lions produce two types of underwater sounds: clicks (or short-duration sound pulses) and barks (Schusterman et al. 1966; Schusterman 1969). All underwater sounds have most of their energy below 4 kHz (Schusterman et al. 1967). The range of maximal sensitivity underwater for sea lions is between 1 and 28 kHz (Schusterman et al. 1972). Functional underwater high-frequency hearing limits are between 35 and 40 kHz, with peak sensitivities from 15 to 30 kHz (Schusterman et al. 1972). The California sea lion shows relatively poor hearing at frequencies below

1,000 Hz (Kastak and Schusterman 1998). The best range of sound detection is from 2 to 16 kHz (Schusterman 1974). Kastak and Schusterman (2002) determined that the species' hearing sensitivity generally worsens with depth—hearing thresholds were lower in shallow water, except at the highest frequency tested (35 kHz), where this trend was reversed. Octave band noise levels of 65 to 70 decibels (dB) above the animal's threshold produced an average Temporary Threshold Shift (TTS) of 4.9 dB in a California sea lion exposed to 1 to 2 kHz for 20 minutes (Kastak et al. 1999).

4.3. Northern Elephant Seal (California Breeding Stock)

Status: The northern elephant seal is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA. The population for the California breeding stock is estimated at 179,000 seals, increasing annually since 1988 (Lowry et al. 2010, 2014; Carretta et al. 2017).

Distribution: Northern elephant seal is common on California coastal mainland and island sites, where the species pups, breeds, rests, and molts. The largest rookeries are on San Nicolas and San Miguel islands in the northern Channel Islands. Near the Bay, elephant seals breed, molt, and haul out at Año Nuevo Island, the Farallon Islands, and Point Reyes National Seashore.

Northern elephant seals haul out to give birth and breed from December through March. Pups remain onshore or in adjacent shallow water through May. Both sexes make two foraging migrations each year: one after breeding and the second after molting (Stewart 1989; Stewart and DeLong 1995). Adult females migrate to the central North Pacific to forage, and males migrate to the Gulf of Alaska to forage (Robinson et al. 2012). Pup mortality is high when they make the first trip to sea in May, and this period correlates with the time of most strandings. Pups of the year return in the late summer and fall, to haul out at breeding rookery and small haul-out sites, but occasionally they may make brief stops in the Bay.

SFOBB Project Area: Generally, only juvenile elephant seals enter the Bay and do not remain long. The most recent sighting near the project area was in 2012, on the beach at Clipper Cove on Treasure Island, when a healthy yearling elephant seal hauled out for approximately 1 day. Approximately 100 juvenile northern elephant seals strand in or

near the Bay each year, including individual strandings at YBI and Treasure Island (less than 10 strandings per year).

Diving and Foraging: Northern elephant seal has the highest diving capacity of any pinniped. Elephant seal juveniles regularly dive for 10 to 15 minutes, with a maximum reported time of 45.5 minutes (Thorson and Le Boeuf 1994; Le Boeuf et al. 1996).

Acoustics: The audiogram of the northern elephant seal indicates that the highest sensitivity range is between 3.2 and 45 kHz, with greatest sensitivity at 6.4 kHz and an upper frequency cutoff of approximately 55 kHz (Kastak and Schusterman 1998).

4.4. Northern Fur Seal (California or Eastern Pacific Stock)

Status: Two stocks may occur near the Bay, the California and Eastern Pacific stocks. The California stock breeds and pups at San Miguel Island (Northern Channel Islands) and the Farallon Islands near San Francisco, with an estimated population of 14,050 sea lions (Carretta et al. 2017). The California northern fur seal stock is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA.

The Eastern Pacific stock breeds and pups on the Pribilof Islands and Bogoslof Island in the Bearing Sea, with an estimated population of 626,734 (Muto et al. 2017). The Eastern Pacific northern fur seal stock is protected under the MMPA and is listed as a strategic and depleted species (Carretta et al. 2012), but is not listed as endangered or threatened under the FESA.

Distribution: Northern fur seal breeds on the offshore islands of California and in the Bering Sea from May through July. The California stock breeds, pups, and forages off the California coast. The Eastern Pacific stock breeds and pups on islands in the Bearing Sea, but females and juveniles move south to California waters to forage in the fall and winter months.

SFOBB Project Area: Both the California and Eastern Pacific stocks forage in the offshore waters of California, but only sick, emaciated, or injured fur seals enter the Bay. The Marine Mammal Center (TMMC) occasionally picks up stranded fur seals around YBI and Treasure Island. The rare occurrence of northern fur seal near the SFOBB east span makes it unlikely that the species will be exposed to implosion activities.

Reproduction and Breeding: Breeding and pupping occur from mid to late May until July. Pups are weaned in September and move south toward the pelagic area offshore from California (Gentry 1998).

Diving and Foraging: The average dive time of northern fur seals is 2.6 minutes, with a maximum between 5 and 7 minutes. The deepest recorded dive is 207 meters (679 feet), but most are between 20 and 140 meters (66 and 460 feet) (Kooyman et al. 1976; Gentry et al. 1986).

Acoustics: Northern fur seals hear from 0.5 to 40 kHz (Moore and Schusterman 1987).

4.5. Common Bottlenose Dolphin (California Coastal Stock)

Status: The common bottlenose dolphin is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA. The population for the California coastal stock was estimated at 453 dolphins (CV= 0.06) based on 2009–2011 surveys (Carretta et al. 2017; Weller et al. 2016). The California coastal stock of bottlenose dolphins remained stable between 1987 and 2005 (Dudzik et al. 2006).

Distribution: This species is found within 0.6 mile (1 kilometer) of shore and occurs from northern Baja California, Mexico to Bodega Bay, with the range extending north over the last several decades related to El Niño events and increased ocean temperatures. An off-shore common bottlenose dolphin stock exists, but genetic studies have shown that no mixing occurs between the two stocks (Lowther-Thieleking et al. 2015).

SFOBB Project Area: As the range of bottlenose dolphins extended north, dolphins began entering the Bay in 2010 (Szczepaniak 2013). Until 2016, most bottlenose dolphins in the Bay were observed in the western Bay, from the Golden Gate Bridge to Oyster Point and Redwood City, although one individual was observed frequently near the former Alameda Air Station (Perlman 2017). In 2017, two individuals have been observed regularly near Alameda (Keener, pers. comm., 2017) and likely passed by the project area.

Diving Behavior: Navy bottlenose dolphins have been trained to reach maximum diving depths of about 300 meters (984 feet) (Ridgway et al. 1969). Reeves et al. (2002) noted that the presence of deep-sea fish in the stomachs of some individual off-shore bottlenose dolphins suggests that they dive to depths of more than 500 meters (1,638 feet). Dive

durations up to 15 minutes have been recorded for trained individuals (Ridgway et al. 1969). Typical dives, however, are more shallow and of a much shorter duration. Bottlenose dolphins use the entire water column by feeding on prey that concentrate near the surface, mid-water areas, and benthic areas (Hastie et al. 2005).

Acoustics: The bottlenose dolphin has a functional high-frequency hearing limit of 160 kHz (Au 1993) and can hear sounds at frequencies as low as 40 to 125 Hz (Turl 1993). The inner ear anatomy of this species has been described (Ketten 1992). The audiogram of the bottlenose dolphin shows that the lowest thresholds occurred near 50 kHz, at a level around 45 dB reference 1 micropascal (re 1 μPa) (Nachtigall et al. 2000; Finneran and Houser 2006; Houser and Finneran 2007). Scientists have reported a range of best sensitivity between 25 and 70 kHz, with peaks in sensitivity occurring at 25 and 50 kHz, at levels of 47 and 46 dB re 1 μPa (Nachtigall et al. 2000).

4.6. Harbor Porpoise (San Francisco–Russian River Stock)

Status: The harbor porpoise is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2014), or listed as endangered or threatened under the FESA. The population for the San Francisco–Russian River stock is estimated at 9,886 porpoises (CV= 0.51), and no recent trend is apparent based on abundance estimates from 2002–2011 (Carretta et al. 2017; Forney et al. 2013).

Distribution: This species seldom is found in waters warmer than 62.6 degrees Fahrenheit (17 degrees Celsius) (Read 1990) or south of Point Conception, and occurs as far north as the Bering Sea (Barlow and Hanan 1995; Carretta et al. 2009; Carretta et al. 2012; Allen and Angliss 2013). The San Francisco–Russian River stock is found from Pescadero, 18 miles (30 kilometers) south of the Bay, to 99 miles (160 kilometers) north of the Bay at Point Arena (Carretta et al. 2012). In most areas, harbor porpoise occurs in small groups, consisting of just a few individuals.

SFOBB Project Area: Harbor porpoises are seen frequently outside the Bay, and they began to re-enter the Bay in 2008. Keener et al. (2012) reports sightings of harbor porpoises from just inside the Bay, northeast to Tiburon and south to the SFOBB west span. In 17 years of monitoring in the project area, 24 harbor porpoises have been observed, and all occurred between 2006 and 2015; including two in 2014, five in 2015 and 15 in 2017. In 2017, the number of harbor porpoises in the project area increased significantly. However, the majority of harbor porpoise observations made during

monitoring for the SFOBB Project have been at distances ranging from 2,438 to 3,048 meters (8,000 to 10,000 feet) from the work area.

Diving Behavior: Harbor porpoise generally are shallow, short duration divers. A study that evaluated the dive duration and depth of 2,878 dives made by a free-swimming harbor porpoise found 90 percent of dives were within the upper 10 meters (32 feet) of the water column and 80 percent were less than 1 minute in duration (Otani et al 2000). In Canadian waters, the maximum dive depth reported was 206 meters (676 feet) and maximum duration was 5.5 minutes (Westgate et al. 1995).

Acoustics: Harbor porpoise vocalizations include clicks and pulses (Ketten 1998), as well as whistle-like signals and echolocation clicks (Verboom and Kastelein 1995), and it is considered to be a high-frequency cetacean (Southall et al. 2007). The main frequency range is 110 to 150 kHz (Ketten 1998), and a behavioral audiogram indicated that the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 μPa-meter (Andersen 1970) and 16 to 140 kHz (Kastelein et al. 2002).

4.7. Gray Whale (Eastern North Pacific)

Status: The gray whale is protected under the MMPA but is not listed as a strategic or depleted species under the MMPA (Carretta et al. 2015), or listed as endangered or threatened under the FESA. The population for the eastern north Pacific stock is estimated at 20,990 whales (CV=0.05) (Durban et al. 2013) and has been stable since the 1990s, with the exception of a UME in 1999–2000 (Carretta et al. 2015).

Distribution: The eastern North Pacific population of gray whales ranges from the southern tip of Baja California, Mexico to the Chukchi and Beaufort Seas (Jefferson et al. 1993). The gray whale makes a well-defined, seasonal north-south migration. Most of the population summers in the shallow waters of the northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea (Rice and Wolman 1971). However, some individuals also summer along the Pacific coast, from Vancouver Island to central California (Rice and Wolman 1971; Darling 1984; Nerini 1984). In October and November, gray whales begin to migrate south and follow the shoreline to breeding grounds along the western coast of Baja California and the southeastern Gulf of California (Braham 1984). Gray whales begin heading north in late winter and early spring (Rice and Wolman 1971). The average gray whale migrates 4,660 to 6,213 miles (7,500 to 10,000 kilometers), at a rate of 91 miles/day (147 kilometers/day) (Jones and Swartz 2002). Gray whales generally

calve and breed during the winter, in lagoons in Baja California (Jones and Swartz 2002), although some calves are born along the California coast during the migration south.

SFOBB Project Area: Reports from TMMC, the Sea Training Institute, the Oceanic Society, Richmond Bridge seal monitors, and local news indicate that since 1999, gray whale sightings in the Bay have become more common, with at least two to six whales entering the Bay annually. Most gray whale sightings have occurred during the spring migration north. Although none have been sighted in the project area, whales have been reported at the northern end of Treasure Island in March, and one sighting was about 914 meters (3,000 feet) south of YBI in December (P. Thorson, pers. comm., 2014). The rare occurrence of gray whales near the SFOBB east span makes it unlikely that the species will be exposed to SFOBB Project implosion activities.

Diving and Foraging: Gray whales typically dive from 50 to 60 meters (164 to 197 feet) for 5 to 8 minutes. In breeding lagoons, the dives usually are less than 6 minutes (Jones and Swartz 2002), although dives as long as 26 minutes have been recorded (Harvey and Mate 1984). When migrating, gray whales may remain submerged near the surface for 7 to 10 minutes, and they travel 500 meters (1,640 feet) or more before resurfacing to breathe. Migrating gray whales sometimes exhibit a unique "snorkeling" behavior, in which they surface cautiously, exposing only the area around the blow hole, exhale quietly without a visible blow, and sink silently beneath the surface (Jones and Swartz 2002).

Only one foraging study has been done on a single animal, off the western coast of Vancouver Island (Malcolm and Duffus 2000; Malcolm et al. 1995/96). The majority of time was spent near the surface on interventilation dives and near the bottom, ranging from a 14 to 22-meter depth (46- to 72-foot depth). Very little time was spent in the water column between the surface and bottom. The whale spent half the time at the surface and on shallow interventilation dives, and half the time diving from 4 to 18 meters (13 to 59 feet).

Acoustics: Gray whales produce broadband signals ranging from 100 Hz to 4 kHz (and up to 12 kHz) (Dahlheim et al. 1984; Jones and Swartz 2002). The most common sounds on the breeding and feeding grounds are knocks (Jones and Swartz 2002), which are broadband pulses from about 100 Hz to 2 kHz, with most produced from 327 to 825 Hz (Richardson et al. 1995). During migration, individuals most often produce low-frequency moans (Crane and Lashkari 1996).

The structure of the gray whale ear has evolved for low-frequency hearing (Ketten 1992). The ability of gray whales to hear frequencies below 2 kHz has been demonstrated in playback studies (Cummings and Thompson 1971; Dahlheim and Ljungblad 1990; Moore and Clarke 2002). Gray whales also are responsive to underwater noise associated with oil and gas activities (Malme et al. 1986; Moore and Clarke 2002). Gray whale responses to noise includes changes in swimming speed and direction, to move away from the sound source; abrupt behavioral changes from feeding to avoidance, with a resumption of feeding after exposure; changes in calling rates and call structure; and surface behavior changes from traveling to milling (e.g., Moore and Clarke 2002).

4.8. Extralimital or Rare Species

The following extralimital species do not enter the Bay regularly but may occur sporadically in the Bay or strand in the Bay. Although these species enter the Bay infrequently, they may be near Piers E6 to E18 during implosion activities, but this is very unlikely.

4.8.1. Southern Sea Otter (California Population)

Southern sea otter (*Enhydra lutris*) is protected under the MMPA and is listed as threatened under the FESA (USFWS 2017, Carretta et al. 2017). The estimated population is 3,272 sea otters (Tinker and Hatfield 2016). Sea otters are common in the near-shore waters from Point Conception to Half Moon Bay, but juvenile sea otters occasionally wander well beyond the observed range limits. Sea otters are not regular visitors to the Bay, but several animals have been observed in the Bay in the last decade (De Rango, pers. comm., 2013).

4.8.2. Humpback Whale (California/Oregon/Washington Stock)

Humpback whale (*Megaptera novaeangliae*) is protected under the MMPA and is listed as a depleted and strategic stock under the MMPA (Carretta et al. 2012). Humpback whale is listed as endangered under the FESA. The current best estimate for the California/Oregon feeding group is 1,729 whales (CV = 0.03); the best estimate of the California, Oregon, Washington stock is 1,918 whales (CV=0.03) (Carretta et al. 2015). Several reports have been made of humpback whales entering the Bay and heading up the Delta waterway. A seasonal influx of whale counts inside the Bay near the Golden Gate Bridge was recorded from April to November in 2016 and 2017 (Keener 2017).

4.8.3. Guadalupe Fur Seal

Guadalupe fur seal (*Arctocephalus townsendi*) is listed as endangered and is protected under the MMPA, being listed as a depleted and strategic stock under the MMPA (Carretta et al. 2015). Guadalupe fur seal is listed as endangered under the FESA. The current best estimate for the Mexico stock is 7,408 fur seals (Carretta et al. 2015), but the population has been increasing in recent years and may be near 20,000 seals (Fahy 2015). Guadalupe fur seals have shown up in greater numbers along the California coast with the warm water condition in the northeastern Pacific Ocean.

4.8.4. Minke Whale (California/Oregon/Washington Stock)

Minke whale (*Balaenoptera acutorostrata scammoni*) is protected under the MMPA and is not listed as a depleted or strategic stock under the MMPA (Carretta et al. 2012). Minke whale is not listed as threatened or endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 636 whales (CV = 0.72) based on line-transect surveys in 2008 and 2014 (Barlow 2016). Minke whales are not regular visitors to the Bay but have been observed several times since the 1980s (De Rango, pers. comm., 2013).

4.8.5. Sperm Whale (California/Oregon/Washington Stock)

Sperm whale (*Physeter macrocephalus*) is protected under the MMPA and is listed as a depleted and strategic stock under the MMPA (Carretta et al. 2012). Sperm whale is listed as endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 2,106 whales (CV = 0.58) (Carretta et al. 2015). Sperm whales are not regular visitors to the Bay, having been observed only once since the 1980s (De Rango, pers. comm., 2013).

4.8.6. Fin Whale (California/Oregon/Washington Stock)

Fin whale (*Balaenoptera physalus physalus*) is protected under the MMPA and is listed as a depleted and strategic stock under the MMPA (Carretta et al. 2012). Fin whale is listed as endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 9,029 whales (CV = 0.12), based on trend-model analysis of line-transect data from 1991 to 2014 (Moore and Barlow 2011, Barlow 2015, Nadeem et al. 2016). Fin whales are not regular visitors to the Bay, having been observed only once since the 1980s (De Rango, pers. comm., 2013).

4.8.7. Steller Sea Lion (Eastern Stock, California Population)

Steller sea lion (*Eumetopias jubatus*) is protected under the MMPA and is not listed as a depleted and strategic stock under the MMPA (Allen and Angliss 2014). The eastern stock of Steller sea lion is no longer listed as threatened under the FESA (NOAA 2013). The current best estimate for the Eastern stock is 71,562 sea lions, which includes Southeast Alaska, British Columbia, Oregon, and California (a new rookery was recognized in Washington in 2015, but counts are not yet included in the data) (Muto et al. 2017). The California region is estimated to have 4,056 sea lions, which includes Año Nuevo, Farallon Islands, and George's Reef. These estimates are based on surveys from 1989 to 2015, with most survey and count efforts for the U.S. in 2013 (Muto et al. 2017). The population of Steller sea lions using central California (Año Nuevo and the Farallon Islands) was relatively stable from 1990 to 2015 (Muto et al. 2017). Steller sea lions are not regular visitors to the Bay, but several animals have stranded in the Bay since the 1980s (De Rango, pers. comm., 2013).

4.8.8. Short-Beaked Common Dolphin (California/Oregon/Washington Stock)

Short-beaked common dolphin (*Delphinus delphis delphis*) is protected under the MMPA and is not listed as a depleted or strategic stock under the MMPA (Carretta et al. 2012). Common dolphin is not listed as threatened or endangered under the FESA. Short-beaked common dolphin is the most abundant cetacean in California waters, although the species tends to be found further off-shore. The current best estimate for the California, Oregon, and Washington stock is 969,861 dolphins (CV =0.17) based on multi-year average abundance estimates from the most recent surveys in 2008 and 2014 (Barlow 2016). Only one report has been made of a short-beaked common dolphin stranding in the Bay since the 1980s (De Rango, pers. comm., 2013).

Chapter 5. Type of Incidental Taking Authorization Requested

The Department requests an IHA, pursuant to Section 101 (a)(5)(A) of the MMPA, for the harassment of marine mammals incidental to activities for the removal and reuse of marine foundations of the original east span of the SFOBB. Sound and pressure levels from the use of controlled charges to implode bridge piers and pile driving have the potential to result in take of marine mammals.

Under the MMPA, "take" is defined as "harass, hurt, capture, kill or collect, or attempt to harass, hurt, capture, kill or collect." Under the 1994 Amendment to the MMPA, harassment is statutorily defined as "any act of pursuit, torment, or annoyance which has the potential to injure or disturb a marine mammal or marine mammal stock in the wild." Harassment that has the potential to injure a marine mammal is defined further as Level A harassment. Harassment that has the potential to disturb a marine mammal by causing disturbance of behavioral patterns, including migration, breathing, nursing, breeding, feeding, or sheltering, but which does not have the potential to injure a marine mammal, is defined further as Level B harassment.

5.1. Implosion of Piers E19 and E20

Underwater blasting can cause behavioral disturbance (Level B harassment), slight or serious injury (Level A harassment), and mortality to marine mammals. NMFS has established sound threshold criteria for take of marine mammals from underwater blasting (Table 4). TTS in an animal's hearing is a specific type of behavioral disturbance (Level B harassment). Permanent Threshold Shift (PTS) in an animal's hearing is a specific type of slight injury (Level A harassment). Level A harassment criteria also have been established for injury to an animal's gastro-intestinal (GI) tract and lungs from blasting. The specific acoustic thresholds depend on the functional group and species of marine mammal. The metrics for these criteria are defined as:

Peak Pressure Level

$$L_{pk} = 20\ Log_{10}\left(P_{pk}/P_{ref}\right) \quad (1)$$

where L_{pk} is the peak level in dB and p_{ref} is the reference pressure of 1µPa;

Sound Exposure Level (SEL)

$$SEL = 10\ Log_{10}\left(\int_0^T \frac{P^2(t)\ dt}{P_{ref}^2 \cdot T_{ref}}\right) \quad (2)$$

where T is the duration of the event, $P^2(t)$ is the instantaneous pressure squared and T_{ref} is the reference time of 1 second;

Impulse

$$I = \int_0^T \left(P(t)dt \Big/ P_{ref}\right) \quad (3)$$

where T is the duration of the initial positive portion of p(t). To calculate these quantities, p(t) for the blast event is needed as a function of distance from the blast, or alternatively, empirical relationship can be used for L_{pk} and I.

As shown in Table 4, different designations for the SEL criteria exist for each group/ species. These refer to group/species-specific filter shapes that are to be applied to the pressure signal. For Peak and Impulse, no filters are specified.

The Department is requesting authorization for incidental take of marine mammals caused by behavioral disturbance and TTS (Level B harassment) during use of controlled charges to implode Piers E19 and E20. Based on calculated sound pressure levels, discussed in Chapter 6, and the implementation of avoidance and minimization measures outlined in Chapter 11, "Mitigation Measures," no injury (Level A harassment) or mortality to marine mammals is anticipated from implosion of Piers E19 and E20.

Table 4. Underwater Sound Pressure Threshold Criteria for Underwater Blasting

Species Hearing Group	Species	Behavior		Slight Injury			Mortality
		Behavioral	TTS	PTS	Gastro-Intestinal Tract	Lung	
Mid-frequency (MF) Cetaceans	Bottlenose Dolphin	165 dB SEL_{cum} (MF)	170 dB SEL_{cum} (MF) 224 dB peak SPL	185 dB SEL_{cum} (MF) 230 dB peak SPL	237 dB peak SPL	39.1 $M^{1/3}$ $(1+[D_{Rm}/10.081])^{1/2}$ Pa-sec Where: M = mass of the animals in kg D_{Rm}= depth of the receiver (animal) in meters	91.4 $M^{1/3}$ $(1+[D_{Rm}/10.081])^{1/2}$ Pa-sec Where: M = mass of the animals in kg D_{Rm}= depth of the receiver (animal) in meters
High-frequency (HF) Cetaceans	Harbor Porpoises	135 dB SEL_{cum} (HF)	140 dB SEL_{cum} (HF) 196 dB peak SPL	155 dB SEL_{cum} (HF) 202 dB peak SPL			
Phocid Pinniped (PW)	Harbor Seal and Elephant Seal	165 dB SEL_{cum} (PW)	170 dB SEL_{cum} (PW) 212 dB peak SPL	185 dB SEL_{cum} (PW) 218 dB peak SPL			
Otariid Pinniped (OW)	Sea Lion and Fur Seal	183 dB SEL_{cum} (OW)	188 dB SEL_{cum} (OW) 226 dB peak SPL	203 dB SEL_{cum} (OW) 232 dB peak SPL			

Note:

SEL_{cum} = Cumulative Sound Exposure Level

Pa-sec = Pascal-second

MF, HF, PW, and OW associated with cumulative sound exposure level thresholds indicate the designated marine mammal auditory weighting function.

Sources: Finneran and Jenkins 2012; NMFS 2016

5.2. Pile Driving for Construction of OTD Pedestrian Bridge

Vibratory pile driving and vibratory pile removal produces non-impulse (continuous) sounds that can cause behavioral disturbance to marine mammals and TTS in an animal's hearing. Both behavioral disturbance and TTS are considered to be Level B harassment. These non-impulse sounds from vibratory pile driving also can cause slight injury, from PTS in an animal's hearing (Level A harassment).

Impact pile driving produces impulse sounds that can cause behavioral disturbance and TTS to marine mammals (Level B harassment) and slight injury, from PTS in an animal's hearing (Level A harassment).

NMFS has established sound threshold criteria for behavioral disturbance (Level B harassment) and PTS (Level A harassment) to marine mammals from pile driving and other similar activities (Table 5). These sound threshold criteria do not apply to explosives. The underwater sound pressure threshold for behavioral disturbance (Level B harassment) is 120 dB root-mean-square (RMS) for non-impulse sound (e.g., vibratory pile driving) and 160 dB RMS for impulse sound (e.g., impact pile driving) for both cetaceans and pinnipeds (Table 5). The underwater sound pressure threshold for slight injury, PTS (Level A harassment) is a dual metric criterion, including both a peak pressure and cumulative SEL (SELcum) threshold that is specific to the species hearing group (i.e., high frequency cetaceans, mid frequency cetaceans, low frequency cetaceans, phocids, and otariids). Underwater sound pressure thresholds for Level B and Level A harassment for each marine mammal taxa from non-impulse and impulse sounds are shown in Table 5. The Peak SPL and SEL metrics used for pile driving sound threshold criteria are the same as those used for underwater blasting defined above. The RMS metric for these criteria is defined as:

$$p_{RMS} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} p^2\,(t)\,dt} \qquad (3)$$

$$L_{RMS} = 20\,Log_{10}\left(p_{rms}/p_{ref}\right)$$

Table 5. Underwater Sound Threshold Criteria for Pile Driving

Species Hearing Group	Non-Impulse Sound (Vibratory Pile Driving)		Impulse Sound (Impact Pile Driving)		
	Level B Harassment	**Level A Harassment**	**Level B Harassment**	**Level A Harassment**	**Level A Harassment**
	Behavioral	**Slight Injury (PTS)**	**Behavioral**	**Slight Injury (PTS) Peak Criteria**	**Slight Injury (PTS) SEL_{cum} Criteria**
High Frequency Cetaceans	120 dB RMS	173 dB SELcum	160 dB RMS	202 dB Peak	155 dB SELcum
Mid Frequency Cetaceans	120 dB RMS	198 dB SELcum	160 dB RMS	230 dB Peak	185 dB SELcum
Phocids	120 dB RMS	201 dB SELcum	160 dB RMS	218 dB Peak	185 dB SELcum
Otariids	120 dB RMS	219 dB SELcum	160 dB RMS	232 dB Peak	203 dB SELcum

Note:

All decibels (dB) are referenced to 1 micro Pascal (re: 1μPa).

Source: NMFS 2010, 2016

5.3. Levels and Types of Marine Mammal Take

The following discussion provides additional information and background on the levels and types of marine mammal take for which NMFS has established threshold criteria.

5.3.1. Behavioral Responses

Generally, a louder source of sound results in a more intense behavioral response. However, other factors, such as the proximity of a sound source, type, and frequency of the sound, and the animal's experience, motivation, and conditioning also are critical factors influencing the response (Southall et al. 2007).

The distance from the sound source and whether it is perceived as approaching or moving away also can affect the type and the intensity of the animal's response to a sound (Richardson et al. 1995, Wartzok et al. 2003, Nowacek et al. 2007; Southall et al. 2007). Behavioral responses can vary, from a minor response (i.e., orientation to the sound or head movement) to a strong response (i.e., rapidly swimming away from the sound, abandonment of the area).

Mid-frequency cetaceans, including sperm whales and bottlenose dolphins, may show no clear tendency in response to sound sources. Captive U.S. Navy bottlenose dolphins sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al. 2002). Sperm whales in the Gulf of Mexico did not show any movement away from a seismic survey ship that was located approximately 2 to 7 nautical miles (3.7 to 13.0 kilometers) away (Madsen et al. 2006; Miller et al. 2009).

High-frequency cetaceans (e.g., harbor porpoises) exhibited changes in respiration and avoidance behavior when exposed to sounds between 90 and 140 dB Peak re 1 μPa. During pile driving, an SPL of 136 dB Peak re 1 μPa caused an increase in the respiratory rate of a captive harbor porpoise, and at 154 dB Peak re 1 μPa, the porpoise jumped out of the water more often (Kastelein et al. 2013).

Phocid seals showed avoidance reactions at or below 190 dB Peak re 1 μPa (Richardson et al. 1995). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pile driving noise with mean underwater levels of 157 dB Peak re 1 μPa and suggested that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulsive source at levels of 165 to 170 dB RMS re 1 μPa (Finneran et al. 2003). Although specific noise level was not necessarily a factor, harbor seals abandoned a haul-out site after being repeatedly disturbed by small boats (Allen et al. 1984).

5.3.2. Hearing Threshold Shifts (TTS and PTS)

The magnitude of TTS or PTS is dependent on the level of sound, frequency, and duration of the sound (Parvin et al. 2007). Recovery from TTS usually occurs within minutes to hours, depending on the severity of the TTS exposure (Nachtigall et al. 2004; Finneran et al. 2005; Mooney et al. 2009). PTS has not been measured in marine mammals because of ethical concerns, but it has been measured in terrestrial animals. For marine mammals, PTS has been assumed to occur at a level about 6 dB above the level that causes TTS.

5.3.3. Injury and Mortality

Injury from impulse sounds, including underwater explosions, usually involves air-filled cavities, such as the lungs, GI tract, and nasal sinuses, as well as the auditory system (Yelverton et al. 1973; Goertner 1982; Craig and Hearn 1998). Damage to the tissues of the brain also may occur (Knudsen and Øen 2003). Impulse injuries to the respiratory system may consist of lung contusions, collapsed lungs, air in the chest cavity between the lungs, traumatic lung cysts, or interstitial or subcutaneous emphysema (Phillips and Richmond 1990). The reinforced trachea, flexible thoracic cavity, and ability to deflate and re-inflate the lungs during diving (Kooyman et al. 1970; Ridgway and Howard 1979) may decrease the risk of lung injury in marine mammals when exposed to loud sounds or pressures. In addition, the GI tract is more robust than lung tissues that require higher pressures for tissue damage to occur.

Mortality to fur seals occurred within 23 meters (75.5 feet) of an 11-kilogram (24.25-pound) submerged dynamite charge (peak pressure of 530 pounds per square inch [psi] [252 dB re 1 µPa; Parvin et al. 2007]). Sea otters were injured when exposed to peak pressures of 100 psi (236 dB re 1 µPa), and mortality occurred at peak pressures of 300 psi (246 dB re 1 µPa) (Parvin et al. 2007). Many marine mammals must breathe quickly when surfacing and undergo lung collapse during deep diving, and thus lung injuries can be particularly debilitating or fatal. Mortalities to bottlenose dolphins also have occurred from underwater explosions associated with oil rig removal in the Gulf of Mexico (Klima et al. 1988) and to long-beaked common dolphins during Navy training in Southern California (Danil and St. Ledger 2011).

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Chapter 6. Take Estimates for Marine Mammals

The distance to marine mammal threshold criteria for underwater blasting activities and pile-driving activities, and the corresponding zones of influence (ZOIs) have been determined based on underwater sound and pressure measurements collected during previous pier implosion activities in the project area and pile-driving activities in the project area and other locations involving similar activities under similar conditions. The numbers of marine mammals by species that may be taken by each type of take were calculated based on distance to the marine mammal threshold criteria, duration of the activity, and the estimated density of each species in the ZOI.

6.1. Estimates of Species Densities of Marine Mammals

No systematic line transect surveys of marine mammals have been performed in the Bay. Therefore, the in-water densities of harbor seals, California sea lions, and harbor porpoises were calculated based on 17 years of observations during monitoring for the SFOBB construction and demolition. Care was taken to eliminate multiple observations of the same animal, although this can be difficult and is likely that the same individual may have been counted multiple times on the same day. The amount of monitoring performed per year varied, depending on the frequency and duration of construction activities with the potential to affect marine mammals. During the 257 days of monitoring from 2000 through 2017 (including 15 days of baseline monitoring in 2003), 1,029 harbor seals, 83 California sea lions, and 24 harbor porpoises were observed in waters in the project vicinity. In 2015, 2016, and 2017, the number of harbor seals in the project area increased significantly. In 2017, the number of harbor porpoise in the project area also increased significantly. Therefore, a harbor seal density estimate was calculated for 2015–2017, and a harbor porpoise density estimate was calculated for 2017, which may better reflect the current use of the project area by these animals.

Insufficient sighting data exist to estimate the density of bottlenose dolphins. However, a single bottlenose dolphin has been observed regularly, south of the SFOBB east span since fall 2016. During monitoring performed in 2017 for the SFOBB, two bottlenose dolphins were observed south of the SFOBB.

Insufficient sighting data exist to estimate elephant seal densities in the Bay. Generally, only juvenile elephant seals enter the Bay and do not remain long. The most recent sighting near the project area was in 2012, on the beach at Clipper Cove on Treasure

Island, when a healthy yearling elephant seal hauled out for approximately 1 day. Approximately 100 juvenile northern elephant seals strand in or near the Bay each year, including individual strandings at YBI and Treasure Island (less than 10 strandings per year).

Insufficient sighting data exist to estimate northern fur seal densities in the Bay. Only two to four northern fur seals strand in the Bay each year, and they are unlikely to occur in the project area.

The size of the areas monitored for marine mammals has increased over the 17 years of observations. The majority of pinniped monitoring has been focused within a 610-meter (2,000-foot) radius of the work area. Although some pinniped observations have been recorded at greater distances, in part because of recent monitoring of larger areas for harbor porpoise zones during pier implosion, a 2-square-kilometer area, corresponding with a 610-meter (2,000-foot) radial distance, was used for density calculations. Harbor porpoise sightings in the Bay have increased in recent years; however, the majority of harbor porpoise observations made during monitoring for the SFOBB Project have been at distances ranging from 2,438 to 3,048 meters (8,000 to 10,000 feet) from the work area. Therefore, harbor porpoise densities were calculated based on a 15-square-kilometer area, corresponding with a 2,438-meter (8,000-foot) radial distance, with land areas subtracted from the area. Numbers used for density calculations are shown in Table 6. Bold densities were used for take calculations.

6.1.1. Pacific Harbor Seal Density Estimates

Most data on harbor seal populations are collected while the seals are hauled out because they are much easier to count when they are out of the water. In-water density estimates rely on haul-out counts, the percentage of seals not on shore based on radio telemetry studies, and the size of the foraging range of the population. Harbor seal density in the water can vary greatly, depending on weather conditions or the availability of prey. For example, during Pacific herring runs further north in the Bay (near Richardson Bay) in February 2014, very few harbor seals were observed foraging near YBI or transiting through the project area for approximately 2 weeks. Sightings went from a high of 27 harbor seal individuals foraging or in transit in 1 day to no seals per day in transit or foraging through the project area (Department 2014). In 2015 and 2016, the number of harbor seal sighting in a day in the project area increased up to 41 seals (Department 2015b, 2016). Calculated harbor seal density (Table 6) is a per day estimate of harbor seals for a 1 square kilometer (100 hectares) area.

Harbor seal density was calculated from all observations during SFOBB Project monitoring from 2000 to 2017, with a second set of density estimates for 2015–2017. These observations included data from baseline, pre-, during, and post-pile driving, mechanical dismantling, on-shore blasting, and off-shore implosion activities.

Table 6. Estimated In-Water Density of Marine Mammals in the SFOBB Project Area

Species Observed	Area of Monitoring Zone (square kilometer)	Days of Monitoring	Number of Animals Observed	Density animals/square kilometer
Harbor Seals 2000 – 2017	2	257	1029	2.002
Harbor Seals 2015 – 2017	2	47	372	**3.957**
Sea Lions 2000 – 2017	2	257	83	**0.161**
Bottlenose Dolphins 2017	2	6	2	Insufficient sighting data exists to estimate density
Harbor Porpoise 2000 – 2017	3	257	24	0.031
Harbor Porpoise 2017	15	6	15	**0.167**
Elephant Seal 2000 – 2017	2	257	0	Insufficient sighting data exists to estimate density
Northern Fur Seal 2000 – 2017	2	257	0	Insufficient sighting data exists to estimate density
Gray Whale 2000 – 2017	2	257	0	Insufficient sighting data exists to estimate density

Notes:
Densities for Pacific harbor seals, California sea lions, and harbor porpoises are based on monitoring for the east span of the SFOBB from 2000 to 2017.
A second set of Pacific harbor seal densities were calculated from the increase in sightings recorded from 2015 to 2017.
A second set of harbor porpoise densities were calculated for the increase in sightings that were recorded in 2017.
Bold densities were used for take calculations.
Sources: Department 2001, 2004b, 2013b, 2013c, 2014, 2015b, 2016, 2017; Perlman 2017.

During this time, the population of harbor seals in the Bay remained stable (Manugian 2013; Manugian et al. 2017). Despite the Bay harbor seal population remaining stable, an increase in daily harbor seal observations occurred during monitoring that was conducted in fall 2015, 2016, and 2017; therefore a separate density was calculated based on the 2015–2017 data. All harbor seal observations during monitoring were used in the estimate. Care was taken to eliminate multiple observations of the same animal, although this was difficult when more than three seals were foraging in the same area.

Density of harbor seals was highest near YBI and Treasure Island, and the foraging areas around Piers E2 to E5 of the new SFOBB east span (Figure 11). Also, an increase

occurred in harbor seals transiting through the area, likely traveling between other foraging areas and haul-out sites. The calculated Pacific harbor seal density was a per day estimate of harbor seals for a 1 square kilometer (100 hectares) area (Table 6).

One of the three primary harbor seal haul-out sites in the Bay is on the southern coast of YBI, approximately 2,134 meters (7,000 feet) from the project area. At least one of the post-blast stranding surveys after each of the six 2016 blast events was completed within 2 hours of low tide, to get a maximum count of seals. The total number of seals hauled out and in the water near the haul-out ranged from 39 to 75 animals.

6.1.2. California Sea Lion Density Estimates

Most data on California sea lion populations are collected while the seals are hauled out because they are much easier to count when they are out of the water. In-water density estimates rely on haul-out counts, the percentage of sea lions not on shore based on radio telemetry studies, and the size of the foraging range of the population. Sea lion density, like harbor seal densities can vary greatly in the water, depending on weather conditions, the availability of prey, and the season. For example, sea lion density increases during summer and fall, after the end of the breeding season at the Southern California rookeries.

In the project area, California sea lion density was calculated from all observations during SFOBB Project monitoring from 2000 to 2017. These observations included data from baseline, pre, during, and post-pile driving, mechanical dismantling, on-shore blasting, and pier implosion activities. All sea lion observations during monitoring for the SFOBB Project were used in the estimate. Care was taken to eliminate multiple observations of the same animal, although most sea lion observations involved a single animal.

Calculated California sea lion density was a per day estimate of sea lions for a 1 square kilometer (100 hectares) area (Table 6).

6.1.3. Northern Elephant Seal Sightings and Occurance in the Bay

Insufficient sighting data exists to estimate elephant seal densities in the Bay. Generally, only juvenile elephant seals enter the Bay and do not remain long. The most recent sighting near the project area was in 2012, on the beach at Clipper Cove on Treasure Island, when a healthy yearling elephant seal hauled out for approximately 1 day. Approximately 100 juvenile northern elephant seals strand in or near the Bay each year, including individual strandings at YBI and Treasure Island (less than 10 strandings per year). Juvenile elephant seals may have stranded after they returned to California in the fall (September through November).

6.1.4. Northern Fur Seal Sightings and Occurance in the Bay

Too few observations of northern fur seals have occurred to determine density. TMMC reported only two to four northern fur seal strandings in the Bay in 2015 and 2016 (in Marin, San Francisco, and Santa Clara counties) (TMMC 2017).

6.1.5. Common Bottlenose Dolphin Sightings and Occurance in the Bay

Insufficient sighting data exists to estimate the density of bottlenose dolphins. Historically, observations of bottlenose dolphins primarily have occurred west of Treasure Island and were concentrated along the nearshore area of San Francisco, south to Redwood City. In 2017, however, two individuals were observed regularly near Alameda (Keener, pers. comm., 2017) and likely passed by the project area.

6.1.6. Harbor Porpoise Density Estimates

Harbor porpoise density was calculated from all observations during SFOBB Project monitoring, from 2000 to 2017. These observations included data from baseline, pre-, during, and post-pile driving, and pier implosion activities. Over this period, the number of harbor porpoises that were observed entering and using the Bay increased. During the 17 years of monitoring in the project area, 24 harbor porpoises were observed, and all occurred between 2006 and 2015, including two in 2014, five in 2015 and 15 in 2017. In 2017, the number of harbor porpoises in the project area increased significantly. Therefore, a harbor porpoise density estimate was calculated for 2017, which may better reflect the current use of the project area by these animals. However, the majority of harbor porpoise observations made during monitoring for the SFOBB Project have been at distances ranging from 2,438 to 3,048 meters (8,000 to 10,000 feet) from the work area. Therefore, harbor porpoise densities were calculated based on a 15 square kilometer area, corresponding with a 2,438-meter (8,000-foot) radial distance, with land areas subtracted from the area. Numbers used for density calculations are shown in Table 6. Calculated harbor porpoise density was a per-day estimate of porpoises for a 1 square kilometer (100 hectares) area.

6.1.7. Gray Whale Sightings and Occurance in the Bay

Insufficient sighting data exist to estimate gray whale densities in the Bay. No observations of gray whales have occurred in the project area. According to TMMC, two to six gray whales enter the Bay each year in late winter through spring (February through April), presumably to feed. Gray whales rarely occur in the Bay from September through December. Furthermore, gray whales are unlikely to be present near the project area during late fall or early winter, when the pier implosions are scheduled to occur.

Gray whales may be present in the project area during vibratory pile driving that may take place year-round and impact pile driving, which is restricted from June through November.

6.2. Implosion of Piers E19 and E20

6.2.1. Distances to Marine Mammal Criteria for Underwater Blasting

As discussed in Chapter 5, NMFS has established sound pressure threshold criteria for take of marine mammals from underwater blasting (Table 4). Hydroacoustic monitoring was performed during the implosions of Piers E3 through E18. Results for this monitoring were used to determine distances to marine mammal threshold criteria for underwater blasting.

The criterion for lung injury and mortality to marine mammals is dependent on the mass of the animal and the depth of the animal in the water column; animals smaller in mass are more susceptible to injury from impulse pressures. The criterion is an impulse metric, expressed in pascal-second or psi-msec (Table 4). The estimated mass of a juvenile fur seal (15 kilograms [33 pounds]), was used in the lung injury and mortality calculations, because this will be the smallest animal potentially to be exposed to the implosions. The depth at which the animal is exposed also affects the criterion threshold calculation. The water depth around Piers E19 and E20 is very shallow, at 3 to 4 meters (10 to 12 feet). Although implosions will take place in shallow areas, marine mammals are more likely to be present in slightly deeper waters. Therefore, an average depth for the project area of 6 meters (20 feet) was used in the threshold calculation.

The Department has decided to use hydroacoustic monitoring results from the implosions of Piers E3 through E18 to estimate distances to marine mammal thresholds for the implosion of Piers E19 and E20 (Department 2015a, 2016).

Measured distances from the implosion of Piers E17 to E18 (two-pier implosion event) were used to estimate distances to threshold criteria for the implosion of Piers E19 and E20. The measured distances to threshold criteria from the previous Pier E17 and E18 implosion event are shown in Tables 7 and 8.

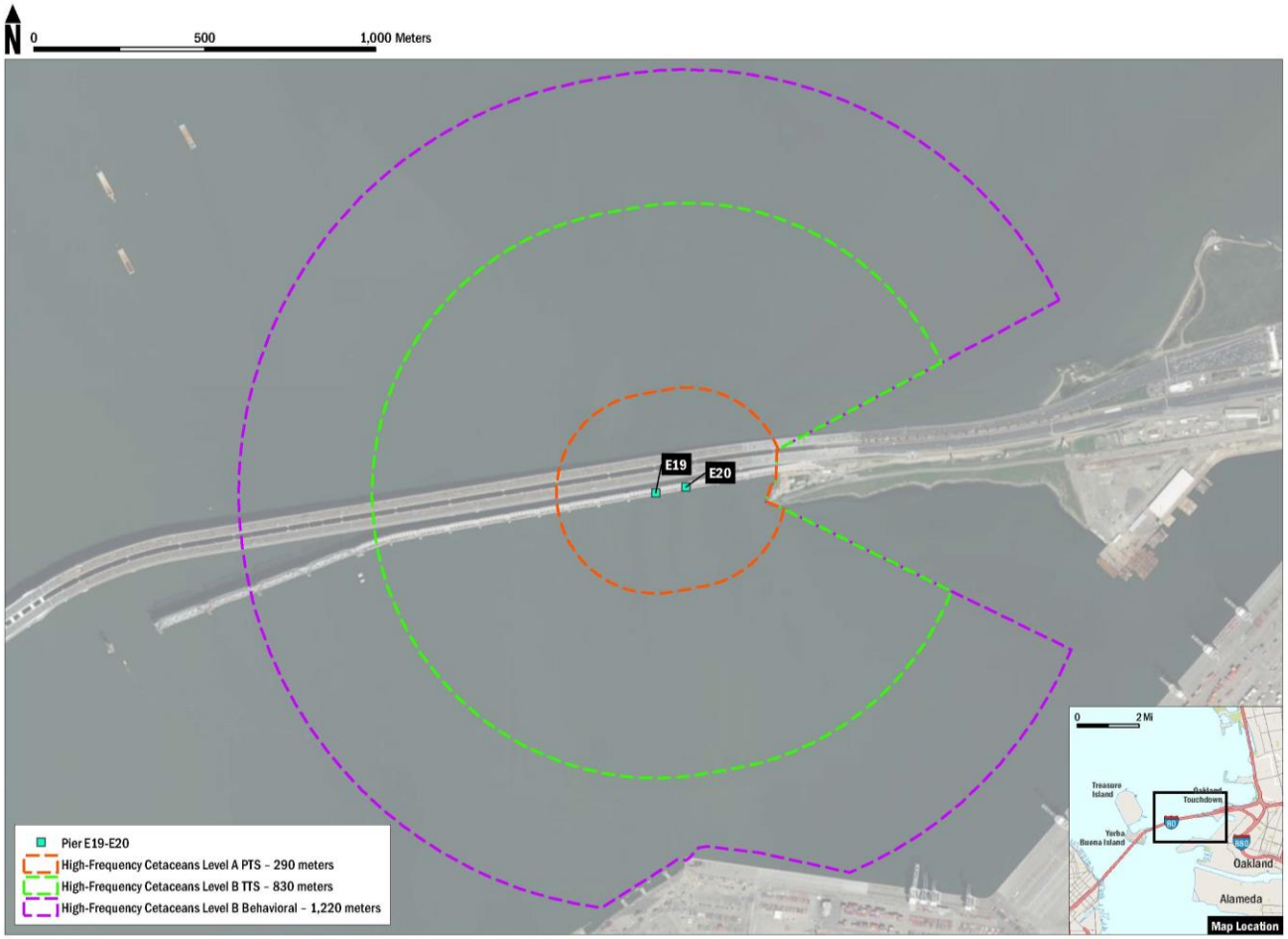
6.2.1. Number of Marine Mammals, by Species, that May be Taken by Implosion of Piers E19 and E20

The numbers of harbor seals, sea lions and harbor porpoise that may be taken by implosion of Piers E19 and E20 were calculated based on distances to the marine mammal threshold criteria, duration of the activity, and the estimated density of these

species in the ZOI. The numbers of elephant seals, northern fur seals and bottlenose dolphin that may be taken by implosion of Piers E19 and E20 were determined based on distances to the marine mammal threshold criteria, duration of the activity, and sightings and occurrence of these species in the Bay, specifically near the project area. Distances to marine mammal threshold criteria were calculated based on the highest sound pressure levels generated during the previous pier implosion of Piers E17 and E18 (two-pier implosion event) .

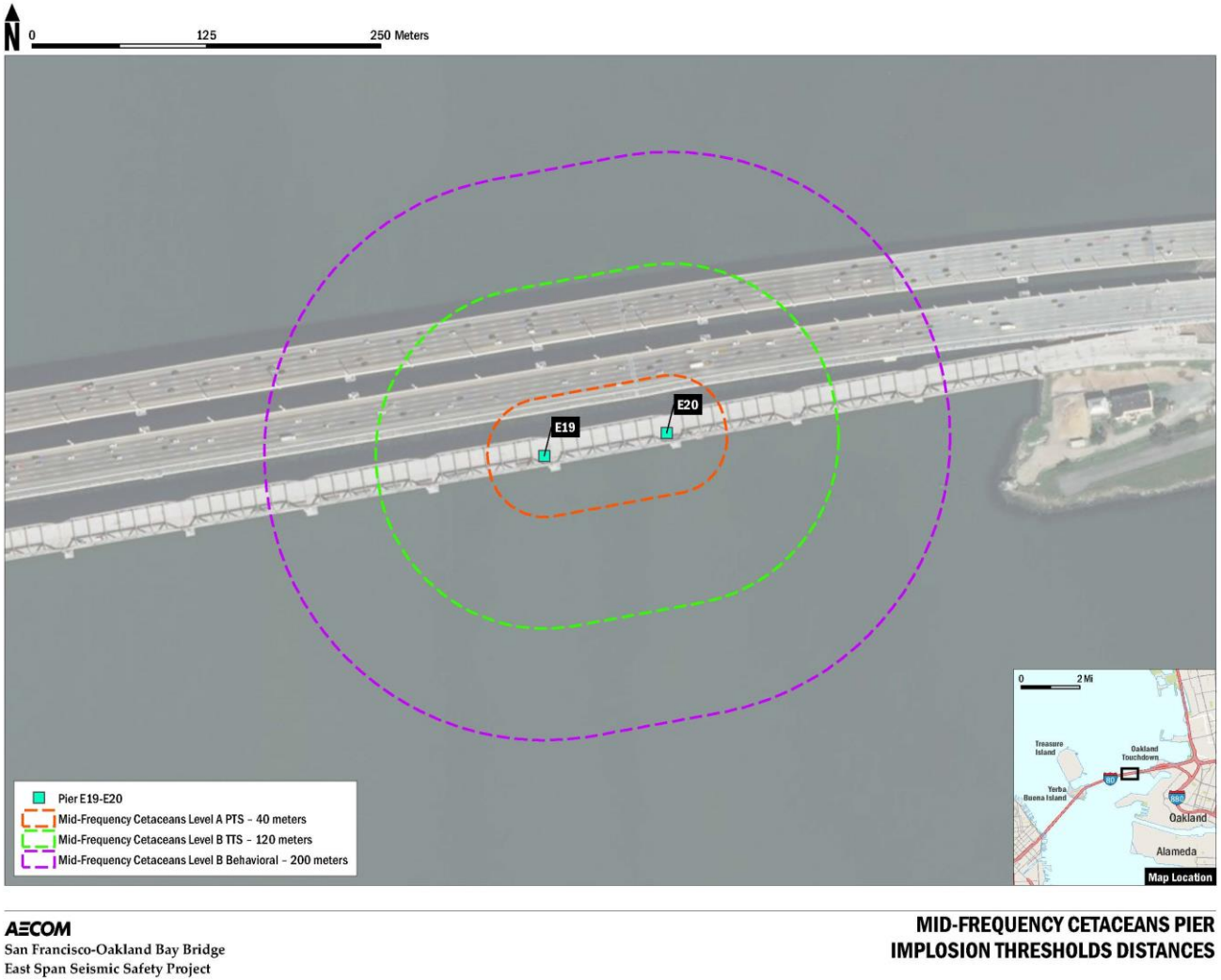
For the pier implosion event, the total area of the ZOI for each threshold criteria was calculated based on isopleth areas shown in Figures 10 through 13 multiplied by the density of the species, for those species that densities could be determined for. The estimated in-water density of each species in the project area (for species that densities could be determined for) is shown in Table 6 and Tables 9 through 11.

The number of exposures of each species was calculated over the entire area of each Level A, Level B, and mortality threshold criteria zone for the proposed pier implosion event (Tables 9 through 11). Based on the distances to the marine mammal threshold criteria and estimated species density, approximately two harbor seals (one by behavioral response and one by TTS) and one harbor porpoise (by behavioral response) may be taken by Level B harassment during the implosion Piers E19 and E20 (Table 12). No take of any other species is anticipated.



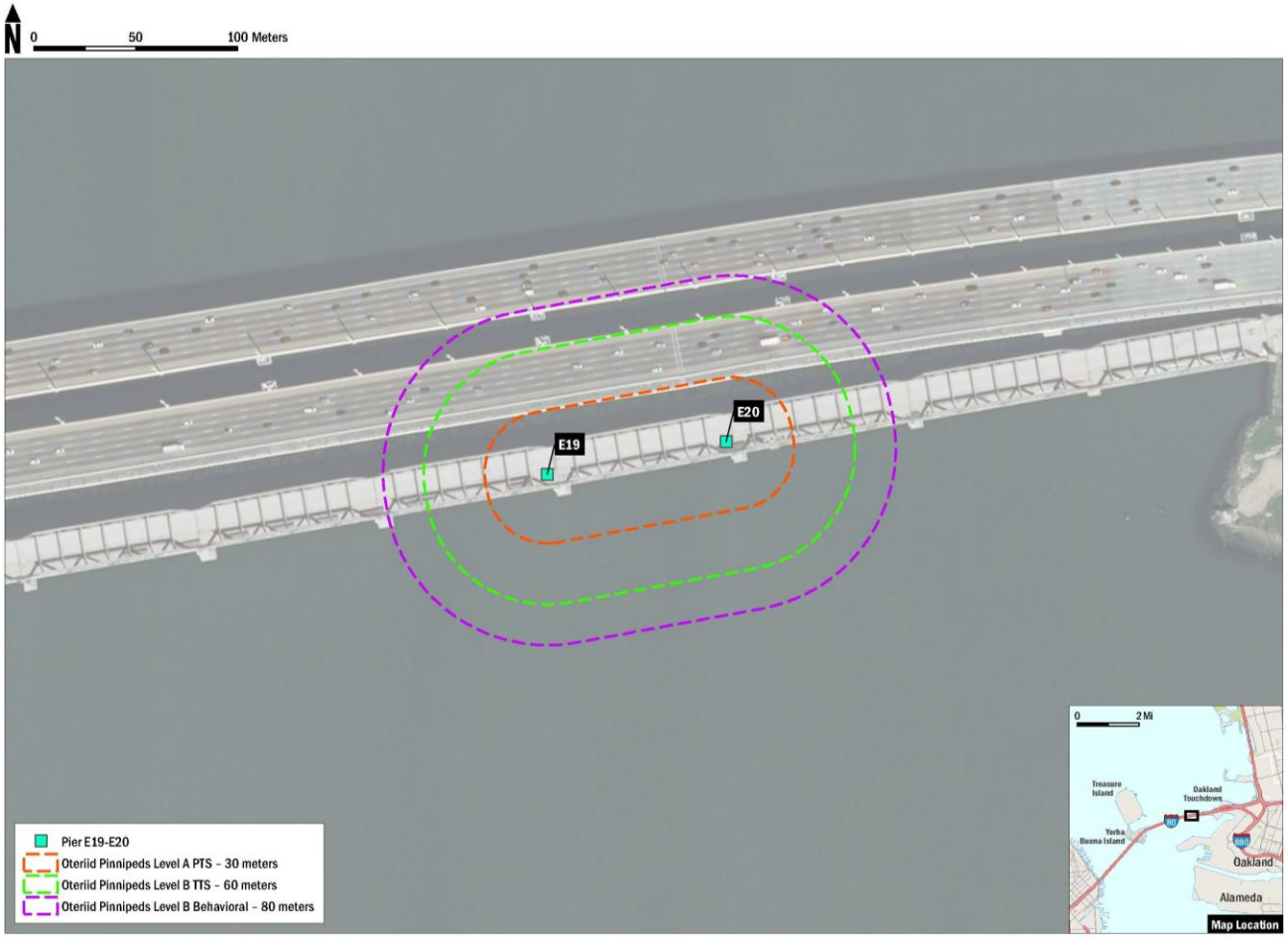
Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 10. High-Frequency Cetaceans Pier Implosion Thresholds Distances



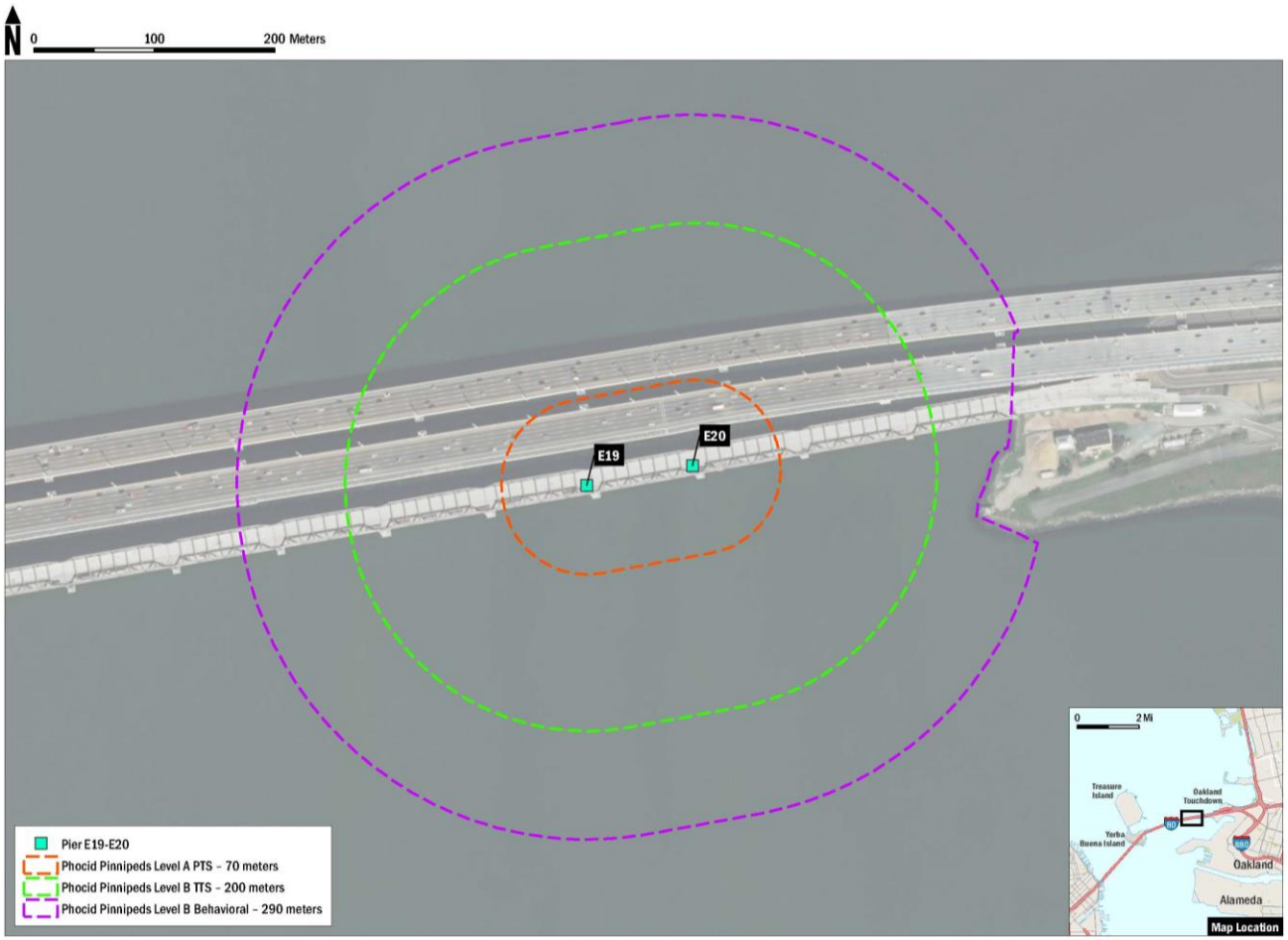
Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 11. Mid-Frequency Cetaceans Pier Implosion Thresholds Distances



Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 12. Oteriid Pinniped Pier Implosion Thresholds Distances



Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 13. Phocid Pinniped Pier Implosion Thresholds Distance

Table 7. Measured Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS from the Previous Implosion of Piers E17 and E18 in a Single Event and Estimated Distances to These Threshold Criteria for the Proposed Implosion of Piers E19 and E20 in a Single Event

Species Hearing Group		**Behavioral**	**TTS[1]**		**PTS[1]**	
Mid-Frequency Cetaceans (Dolphins)	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Piers E17- E18 Measured	511 feet	134 feet	**359 feet**	89 feet	**124 feet**
	Piers E19-E20 Estimate	200 meters (656 feet)	50 meters (164 feet)	**120 meters (394 feet)**	30 meters (98 feet)	**40 meters (131 feet)**
High-Frequency Cetaceans (Porpoises)	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Piers E17- E18 Measured	3,747 feet	916 feet	**2,633 feet**	607 feet	**913 feet**
	Piers E19-E20 Estimate	1,220 meters (4,003 feet)	290 meters (951 feet)	**830 meters (2,723 feet)**	200 meters (656 feet)	**290 meters (951 feet)**
Phocid Pinnipeds (Seals)	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Piers E17- E18 Measured	914 feet	305 feet	**641 feet**	202 feet	**221 feet**
	Piers E19-E20 Estimate	290 meters (951 feet)	100 meters (328 feet)	**200 meters (656 feet)**	70 meters (230 feet)	**70 meters (230 feet)**
Otariid Pinnipeds (Sea Lions)	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Piers E17- E18 Measured	249 feet	117 feet	**174 feet**	**77 feet**	60 feet
	Piers E19-E20 Estimate	80 meters (262 feet)	40 meters (131 feet)	**60 meters (197 feet)**	**30 meters (98 feet)**	20 meters (66 feet)

Notes:

1. For the TTS and PTS criteria thresholds with dual criteria, the largest criteria distances (i.e., more conservative) are shown in **bold**.

Threshold Source: NMFS 2016

Isopleth Distance Sources: Estimated distances to threshold criteria for the implosion of two small piers were determined based on measured distance to threshold criteria from the implosion of Piers E17 and E18.

Table 8. Estimated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Pier E3, Two Small Piers and Four Small Piers

Species		**GI Tract**		**Lung[1]**	**Mortality[1]**
All Species	Threshold	237 dB Peak	104 psi	$39.1\ (15\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 122 Pa-sec	$91.4\ (15\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 285 Pa-sec
	Piers E17-E18 Measured	55 feet	55 feet	< 40 feet	< 40 feet
	Pier Implosion Estimate	27 meters (89 feet)	27 meters (89 feet)	< 12 meters (< 40 feet)	< 12 meters (< 40 feet)

Notes:

Lung injury and mortality threshold calculations are for a 15-kilogram (33-pound) juvenile fur seal, the smallest marine mammal with the potential to be present in the project area.

Threshold Source: Finneran and Jenkins 2012

Isopleth Distance Sources: Estimated distances to threshold criteria for the implosion of piers were determined based on measured distance to threshold criteria from the implosions of Pier E4, Piers E17 to E18, Piers E11 to E13 and Piers E14 to E16.

Table 9. Level B Behavioral Take Calculations for Implosion of Piers E19 and E20

Species	Species Density (animals/ square kilometer)	Species Density (animals/ square meters)	Level B ZOI radii (meters)	Level B Behavioral ZOI Area (square meters)	Level B Behavioral Take	Number of Two Pier Implosion Events	Level B Take Calculated
Harbor Seal	3.957	3.96E-06	290	315798.486	1.2496	1	1.2496
Sea Lion	0.161	1.61E-07	80	36118.343	0.0058	1	0.0058
Harbor Porpoise	0.167	1.67E-07	1,220	4256937.444	0.7109	1	0.7109
Bottlenose Dolphin	NA	NA	200	125663.706	NA	1	NA
Elephant Seal	NA	NA	290	264207.942	NA	1	NA
Fur Seal	NA	NA	80	20106.19	NA	1	NA

Density Source: Table 6
ZOI Source: Tables 7, 8, and 9
Take Source: Calculated by AECOM in 2017

Table 10. Level B TTS Take Calculations for Implosion of Piers E19 and E20

Species	Species Density (animals/ square kilometer)	Species Density (animals/ square meters)	Level B ZOI radii (meters)	Level B TTS ZOI Area (square meters)	Level B TTS Take	Number of Two Pier Implosion Events	Level B Take Calculated
Harbor Seal	3.957	3.96E-06	200	164964.771	0.6528	1	0.6528
Sea Lion	0.161	1.61E-07	60	23434.268	0.0038	1	0.0038
Harbor Porpoise	0.167	1.67E-07	830	2085701.996	0.3483	1	0.3483
Bottlenose Dolphin	NA	NA	120	45238.934	NA	1	NA
Elephant Seal	NA	NA	200	125663.706	NA	1	NA
Fur Seal	NA	NA	60	11309.73	NA	1	NA

Density Source: Table 6
ZOI Source: Tables 7, 8, and 9
Take Source: Calculated by AECOM in 2017

Table 11. Level A PTS Take Calculations for Implosion of Piers E19 and E20

Species	Species Density (animals/ square kilometer)	Species Density (animals/ square meters)	Level A ZOI radii (meters)	Level A PTS ZOI Area (square meters)	Level A PTS Take	Number of Two Pier Implosion Events	Level B Take Calculated
Harbor Seal	3.957	3.96E-06	70	29462.347	0.1166	1	0.1166
Sea Lion	0.161	1.61E-07	30	9118.458	0.0015	1	0.0015
Harbor Porpoise	0.167	1.67E-07	290	315798.484	0.0527	1	0.0527
Bottlenose Dolphin	NA	NA	40	5026.548	NA	1	NA
Elephant Seal	NA	NA	70	15393.804	NA	1	NA
Fur Seal	NA	NA	30	2827.43	NA	1	NA

Density Source: Table 6
ZOI Source: Tables 7, 8, and 9
Take Source: Calculated by AECOM in 2017

Table 12. Combined Estimated Exposures of Marine Mammals to the Pier Implosions for Levels A and B, and Mortality Threshold Criteria

Species	Level B Exposures For All Implosions		Level A Exposures[1]			Mortality[1]
	Behavioral Response	Temporary Threshold Shift	Permanent Threshold Shift	Gastro-Intestinal Track Injury	Slight Lung Injury	
Pacific Harbor Seal	1	1	0	0	0	0
California Sea Lion	0	0	0	0	0	0
Northern Elephant Seal	0	0	0	0	0	0
Northern Fur Seal	0	0	0	0	0	0
Bottlenose Dolphin	0	0	0	0	0	0
Harbor Porpoise	1	0	0	0	0	0
Total	2	1	0	0	0	0

Note:

1. No implosion will occur if any marine mammal is within the Level A or mortality threshold criteria zones.

Source: Calculated by AECOM in 2017

6.2.1. Species Impacts from the Implosion of Pier E2 and Piers E19 to E22

Pacific Harbor Seal: Harbor seal is the most numerous marine mammal in the Bay and most likely to be in the vicinity of the piers. Most of the observations made during monitoring for the SFOBB Project have been in the vicinity of YBI and the main navigation channel. Seals are less frequently observed in the shallow water areas near the Oakland shoreline where the implosion of Piers E19 and E20 will take place.

No harbor seals will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. The BAS will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. Because of the force of the bubble flux and absence of buoyancy in the bubble field, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If a harbor seal remains undetected and enters the established Level A PTS marine mammal exclusion zone (MMEZ) during the implosion event, it may be subject to slight inner ear injury (PTS). However, active monitoring will be implemented so that harbor seals at the surface will be detected by observers. The long dive durations of harbor seals (mean of 4.7–5.5 minutes, with a maximum of 30 minutes, although 95 percent of dives are under 10 minutes, especially when swimming or foraging) (Eguchi and Harvey 2005) suggest that an individual can swim through the established MMEZ without surfacing. To reduce this possibility, the implosion will be delayed if a harbor seal is observed in the MMEZ. The implosion will not proceed until the individual leaves the MMEZ or at least 15 minutes have passed since the last observation.

Behavioral responses by harbor seals to the implosion may involve rapid movement away from and short-term abandonment of the area. Alternatively, seals foraging in United States Coast Guard and Clipper coves may continue foraging as they have done during pile driving, previous pier implosion events, and other marine construction activities. Long-term abandonment of the area is not expected because project construction has been ongoing since 2003, including previous implosion events in 2015, 2016 and 2017, with continued use of the area by harbor seals.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria 2 harbor seals may be exposed to sound pressure levels that can result in Level B harassment (Table 12). One of those exposures would be within the Level B behavioral response ZOI, and one would be within the TTS ZOI (Table 12). No harbor seals are estimated to be exposed to SPLs that can result in Level A PTS take. Furthermore, because of the

measures to be implemented before the controlled implosion of the piers, such as activation of the BAS and the monitoring in place to detect harbor seals at the surface, no harbor seals are expected to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

California Sea Lion: California sea lion is the second most numerous marine mammal species in the Bay, after the harbor seal. California sea lions may occur in the vicinity of the piers during the implosion, but similar to the discussion for harbor seals, California sea lions at the surface are likely to be detected by the observers during monitoring. Unlike harbor seals, sea lions are not long-duration divers, and no sea lion is likely to swim through the MMEZ without surfacing and being detected. In addition, sea lions tend to spend more time at the surface while swimming than do harbor seals.

No California sea lions will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. As discussed above, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If a sea lion remains undetected and enters the established Level A PTS exclusion zone during an implosion event, it may be subject to slight inner ear injury (PTS). Behavioral responses of sea lions to the controlled implosion are likely to include rapid movement away from and short-term abandonment of the area. As with harbor seals, long-term abandonment of the area by sea lions is not expected because project construction has been ongoing since 2003, including the implosion events in 2015, 2016 and 2017, with continued use of the area.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria no sea lions would be exposed to the SPLs that can result in Level B harassment (Table 12). Because of the avoidance and minimization measures to be implemented before the controlled implosion, such as activation of the BAS and the monitoring in place to detect sea lions at the surface, no sea lions are anticipated to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

Northern Elephant Seal: Northern elephant seals are found infrequently near Treasure Island and are unlikely to be in the vicinity of the pier implosion. Elephant seals at the surface are likely to be detected by the observers during monitoring before the controlled implosions. However, elephant seals are very long-duration divers, which suggests that an individual can swim through the MMEZ without surfacing, although many of the elephant seals that enter the project area may be ill or starving, and therefore their diving ability will be greatly reduced.

The implosion will be delayed if an elephant seal is observed in the MMEZ. The implosion will not proceed until the individual leaves the MMEZ or at least 15 minutes have passed since the last observation.

No elephant seals will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. As discussed above, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If an elephant seal remains undetected and enters the established Level A PTS exclusion zone during the implosion, it may be subject to slight inner ear injury (PTS). Behavioral responses of elephant seals to the controlled implosion likely will include rapid movement away from and short-term abandonment of the area. Long-term abandonment of the area by elephant seals is not expected because project construction has been ongoing since 2003, with limited, continued use of the area for transit or resting.

Because of the infrequent observation of this species in the Bay, the Department estimates that no elephant seals will be exposed to SPLs that can result in Level B harassment (Table 12). Because of the avoidance and minimization measures that will be implemented before the controlled implosion, such as activation of the BAS and monitoring in place to detect elephant seals at the surface, no elephant seals are anticipated to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

Northern Fur Seal: Northern fur seals are found infrequently in the Bay and are unlikely to be in the vicinity of the pier implosion. Northern fur seals at the surface are likely to be detected by the observers during monitoring before the controlled implosions. The implosion will be delayed if an elephant seal is observed in the MMEZ. The implosion will not proceed until the individual leaves the MMEZ or at least 15 minutes have passed since the last observation.

No northern fur seals will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. As discussed above, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If a northern fur seal remains undetected and enters the established Level A PTS exclusion zone during the implosion, it may be subject to slight inner ear injury (PTS). Behavioral responses of fur seals to the controlled implosion likely will include rapid movement away

from and short-term abandonment of the area. Long-term abandonment of the project area by this species is not expected, as this species currently does not use the project area.

Based on the small number, rare occurrence, and the distances to the marine mammal threshold criteria no fur seals would be exposed to SPLs that can result in Level B harassment (Table 12). Because of the avoidance and minimization measures that will be implemented before the controlled implosion, such as activation of the BAS and monitoring in place to detect fur seals at the surface, no fur seals are anticipated to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

Harbor Porpoises: This species rarely occurs in the immediate vicinity of Piers E9 and E20. In 2017, the number of harbor porpoise observed during monitoring for the SFOBB Project increased significantly. However, the majority of these harbor porpoise observations were at distances ranging from 2,438 to 3,048 meters (8,000 to 10,000 feet) from the work area. Their common behavior of traveling in pods of two or more animals along with frequent surfacing events make it very likely that observers will detect any harbor porpoises in the MMEZ.

No harbor porpoise will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. As discussed above, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If a harbor porpoise remains undetected and enters the established Level A PTS exclusion zone during the implosion, it may be subject to slight inner ear injury (PTS). Behavioral responses of harbor porpoises from the controlled implosion are likely to be rapid movement away from and short-term abandonment of the project area. Long-term abandonment is not expected because project construction has been ongoing since 2003, with continued and increased use of the general area by this species.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria, 1 harbor porpoise (by behavioral response) may be taken by Level B harassment during the implosion of Piers E19 and E20 (Table 12). Because of the avoidance and minimization measures that will be implemented before the controlled implosion, such as activation of the BAS and the monitoring in-place to detect harbor porpoises at the surface, no individuals are anticipated to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

Bottlenose Dolphin: Only small numbers of this species occur in the project vicinity. Their common behavior of traveling in pods of two or more animals along with frequent surfacing events make it very likely that observers will detect any bottlenose dolphins in the MMEZ.

No bottlenose dolphins will be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 27 meters (89 feet) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 30 meters (100 feet) from the pier. As discussed above, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs.

If a bottlenose dolphin remains undetected and enters the established Level A PTS exclusion zone during the implosion, it may be subject to slight inner ear injury (PTS). Behavioral responses of bottlenose dolphins from the controlled implosions are likely to be rapid movement away from and short-term abandonment of the project area. Long-term abandonment is not expected because only limited use of the area has occurred.

Based on the low number of individuals in the Bay and the distances to the marine mammal threshold criteria no bottlenose dolphins would be exposed to SPLs that can result in Level B harassment (Table 12). Because of the avoidance and minimization measures that will be implemented before the controlled implosion, such as activation of the BAS and the monitoring in-place to detect bottlenose dolphins at the surface, no individuals are anticipated to be exposed to SPLs that will result in Level A PTS, lung or GI tract injury, or mortality.

6.2.2. Amount of Take Requested for the Implosion of Piers E6 to E18

The estimated number of marine mammals to be exposed to implosion SPLs for each threshold criteria (Table 12) are based on current density estimates or occurrence of marine mammals in the project area (Table 6 and Tables 9 through 11). However, the number of marine mammals in the area at any given time is highly variable. Animal movement depends on time of day, tide levels, weather, and availability and distribution of prey species. Therefore, the Department requests the following number of allowable harassment takes for each Level B harassment criteria threshold (Table 13).

Pacific Harbor Seal: As discussed above, harbor seal is the most numerous marine mammal in the Bay. However, take calculated based on species density and the distances to the marine mammal threshold criteria indicated that only two harbor seals would be exposed to sound pressure levels that can result in Level B harassment (Table 12). One of those exposures would be within the Level B behavioral response ZOI, and one would be within the TTS ZOI (Table 12). Based on previous monitoring the number of harbor seals in the water can vary greatly, depending on weather conditions or the availability of prey. For example, during Pacific

herring runs further north in the Bay (near Richardson Bay) in February 2014, very few harbor seals were observed foraging near YBI or transiting through the project area for approximately 2 weeks. Sightings went from a high of 27 harbor seal individuals foraging or in transit in one day to no seals per day in transit or foraging through the project area (Department 2014). In 2015 and 2016, the number of harbor seal sighting in a single day in the project area increased up to 41 seals (Department 2015b, 2016). Because of this high degree of variability, and the observation of up to 41 seals in the project area in a single day we are requesting authorization for the take of 30 harbor seals by Level B harassment (20 by Level B behavioral response and 10 by Level B TTS) (Table 13).

California Sea Lion: As discussed above, California sea lion is the second most numerous marine mammal species in the Bay, after the harbor seal. However, take calculated based on species density and the distances to the marine mammal threshold criteria indicated that no sea lions would be exposed to sound pressure levels that can result in Level B harassment (Table 12). Based on previous monitoring the number of sea lions transiting through or foraging in the project area can vary greatly. Because of the high degree of variability, regular observation of sea lions in the project area, and because this species may travel in groups we are requesting authorization for the take of seven sea lions (four by Level B behavioral response and three by Level B TTS) (Table 13).

Harbor Porpoises: Based on the calculated density estimates and the distances to the marine mammal threshold criteria, one harbor porpoise (by behavioral response) may be taken by Level B harassment during the implosion of Piers E19 and E20 (Table 12). However the number of harbor porpoise in the Bay and their foraging range appears to be steadily increasing. This high-frequency cetacean has a large ZOI, because of its sensitivity to anthropogenic sound. Further, this species generally travels in either calf cow pairs or small pods of four to five porpoises. For these reasons we are requesting authorization for the take of 10 harbor porpoise (five by Level B behavioral response and five by Level B TTS) (Table 13).

Northern Elephant Seal: As discussed above, because of the infrequent observation of this species in the Bay, the Department estimates that no elephant seals will be exposed to SPLs that can result in Level B harassment (Table 12). However, the number of elephant seals that may enter and or strand in the Bay in a given year is highly variable; dependent on changes in oceanographic conditions, effecting water temperature and prey availability. The Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of three elephant seals (two by Level B behavioral response and one by Level B TTS) (Table 13).

Northern Fur Seal: As discussed above, northern fur seals are found infrequently in the Bay and are unlikely to be in the vicinity of the pier implosion. However, the number of fur seals that may enter and or strand in the Bay in a given year is highly variable; dependent on changes in oceanographic conditions, effecting water temperature and prey availability. The Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of three northern fur seals (two by Level B behavioral response and one by Level B TTS) (Table 13).

Bottlenose Dolphin: As discussed above, only small numbers of bottlenose dolphin occur in the project vicinity. Based on the low number of individuals in the Bay and the distances to the marine mammal threshold criteria the Department anticipates that no bottlenose dolphins would be exposed to SPLs that can result in Level B harassment. However, as discussed in Chapter 4, until 2016, most bottlenose dolphins in the Bay were observed in the western Bay, from the Golden Gate Bridge to Oyster Point and Redwood City, although one individual was observed frequently near the former Alameda Air Station (Perlman 2017). As of 2017, the same two individuals have been observed regularly near Alameda (Keener, pers. comm., 2017) and likely pass by the project area. If additional individuals begin using this eastern area of the Bay, the number of bottlenose dolphin sightings near the project area will likely increase. Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of six bottlenose dolphins (four by Level B behavioral response and two by Level B TTS) (Table 13).

Table 13. Amount of Level B Harassment Take Requested for the Implosions of Pier E2 and Piers E19 to E22

Species	Level B Harassment Take[1]	
	Behavioral Response	Temporary Threshold Shift
Pacific Harbor Seal	20	10
California Sea Lion	4	3
Northern Elephant Seal	2	1
Northern Fur Seal	2	1
Harbor Porpoise	5	5
Bottlenose Dolphin	4	2
Total	42	25

Note:

1. Pier implosion will be delayed if any marine mammals are detected within any of the Level A or mortality threshold criteria exclusion zones.

6.2.3. Test Blasts

In addition to the implosion of Piers E19 and E20, one to two test blasts may be conducted before the pier implosion event. Test blasts are small charges that are used to test the BAS and acoustic monitoring equipment before a controlled implosion. The BAS will be in operation during all tests. The tests will use a charge weight of approximately 18 grain (0.0025 pound).

During previous test blasts, measured SPLs did not reach or exceed marine mammal threshold criteria, beyond the bubble flux of the BAS. Table 14 shows measured SPLs from the Pier E5 test blasts, compared to phocid and high-frequency cetacean threshold criteria, at a distance of 30 meters (100 feet) from the blast (just outside the BAS). The ZOI for all other species hearing groups are smaller than those of phocid and high-frequency cetacean. It will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs. Therefore, no harassment takes are allotted for test blasts. As a conservative measure, one marine mammal observer (MMO) will be on-site during all test blasts, to monitor the movement and response of marine mammals in the area.

Table 14. Measured Pier E5 Test Blast Sound Levels Compared to Phocid and High-Frequency Cetacean Threshold Criteria

Species Group	Threshold	Pier E5 Measured Test Blast Levels at 30 meters (100 feet)
Phocid (Seals)	**Behavioral Response**	
	165 dB SEL_{cum} (P_{WI})	134.4 to 138.3 dB SEL_{cum} (P_{WI})
	TTS	
	170 dB SEL_{cum} (P_{WI})	134.4 to 138.3 dB SEL_{cum} (P_{WI})
	212 dB peak SPL	150.6 to 157.1 dB peak SPL
	PTS	
	185 dB SEL_{cum} (P_{WI})	134.4 to 138.3 dB SEL_{cum} (P_{WI})
	218 dB peak SPL	150.6 to 157.1 dB peak SPL
High-Frequency Cetaceans (Porpoise)	**Behavioral Response**	
	135 dB SEL_{cum} (HF_{II})	118.5 to 124.4 dB SEL_{cum} (HF_{II})
	TTS	
	140 dB SEL_{cum} (HF_{II})	118.5 to 124.4 dB SEL_{cum} (HF_{II})
	196 dB peak SPL	150.6 to 157.1 dB peak SPL
	PTS	
	155 dB SEL_{cum} (HF_{II})	118.5 to 124.4 dB SEL_{cum} (HF_{II})
	202 dB peak SPL	150.6 to 157.1 dB peak SPL

Note:

The thresholds for phocid pinnipeds and high-frequency cetaceans are lower than the thresholds for other pinniped and cetaceans. Therefore, take of any marine mammal species during test blast activities is not anticipated.

Threshold Source: NMFS 2016a

Measured Test Levels Source: Appendix A

6.3. Pile Driving and Pile Removal Activities

6.3.1. Distances to Marine Mammal Criteria for Pile Driving and Pile Removal Activities

As discussed in Chapter 5, "Type of Incidental Taking Authorization Requested," NMFS has established sound threshold criteria for behavioral disturbance (Level B harassment) and PTS (Level A harassment) to marine mammals from pile driving and other similar activities (Table 5). The Department is proposing:

- vibratory driving of H-piles;
- vibratory driving of steel pipe piles equal to or less than 36 inches (0.91 meter) in diameter;

- attenuated (i.e., bubble curtain) impact driving steel pipe piles equal to or less than 36 inches (0.91 meter) in diameter;
- attenuated impact driving of concrete piles equal to or less than 36 inches (0.91 meters) in diameter;
- unattenuated (i.e., no bubble curtain) impact diving of concrete piles equal to or less than 24 inches (0.61 meter) in diameter;
- unattenuated impact hammer proof testing of H-piles; and
- unattenuated impact hammer proof testing of steel pipe piles equal to or less than 36 inches (0.91 meter) in diameter.

The distance to the marine mammal threshold criteria for vibratory and impact driving were calculated based on hydroacoustic measurements collected during previous pile-driving activities for the SFOBB Project and other projects, involving similar activities under similar conditions. Measured sound pressure levels from other projects came from the Department's *Compendium of Pile Driving Sound Data* (Department 2007), which provides information on sound pressures resulting from pile driving measured throughout Northern California. Distances to marine mammal threshold criteria were calculated for all pile types and installation methods listed above. These distances were calculated using the NMFS-provided companion *User Spreadsheet*. Inputs for the *User Spreadsheet* are provided in Table 15.

For calculation of SEL_{cum} threshold distances, the following assumptions were made:

- Only one type/size of pile will be installed on the same day.
- Only one pile installation method, impact or vibratory, will be performed on the same day.
- A maximum of four steel pipe piles will be installed (impact driving or vibratory) on the same day.
- A maximum of six H-piles will be installed (impact or vibratory) on the same day.
- A maximum of two pile will be proof-tested with an impact hammer on the same day; administering a maximum of 20 strikes per pile.

The distances to the marine mammal threshold criteria for these pile driving and pile removal activities are shown in Table 16.

Table 15. User Spreadsheet Inputs

Vibratory Driving of Steel Piles	**H-Pile (Vibratory)**	**24 inch steel (Vibratory)**	**36 inch steel (Vibratory)**
Spreadsheet Tab Used	A)Non-Impulsive, Cont	A)Non-Impulsive, Cont	A)Non-Impulsive, Cont
Source Level (RMS SPL)	150	165	170
Weighting Factor Adjustment (kHz)	2.5	2.5	2.5
a) Activity Duration (h) within 24-h period	0.5	1	1.333333
Propagation (xLogR)	15	15	15
Distance of source level (meters)+	10	10	10
Other factors			
Impact Driving of Steel Piles	**H-Pile (Impact)**	**24 inch steel (Impact)**	**36 inch steel (Impact)**
Spreadsheet Tab Used	E.1) Impact pile driving	E.1) Impact pile driving	E.1) Impact pile driving
Source Level (Single Strike/shot SEL)	160	167*	170*
Weighting Factor Adjustment (kHz)	2	2	2
a) Number of strikes in 1 h	200	450	600
a) Activity Duration (h) within 24-h period	6	4	4
Propagation (xLogR)	15	15	15
Distance of source level (meters)+	10	10	10
Other factors		Using Bubble Curtain *	Using Bubble Curtain*
Pile Proofing (Impact)	**H-Pile (Impact)**	**24 inch steel (Impact)**	**36 inch steel (Impact)**
Spreadsheet Tab Used	E.1) Impact pile driving	E.1) Impact pile driving	E.1) Impact pile driving
Source Level (Single Strike/shot SEL)	160	177	180
Weighting Factor Adjustment (kHz)	2	2	2
a) Number of strikes in 1 h	20	20	20
a) Activity Duration (h) within 24-h period	2	2	2
Propagation (xLogR)	15	15	15
Distance of source level (meters)+	10	10	10
Other factors			

Impact Driving of Concrete Piles	**24 inch concrete (Impact)**	**36 inch concrete (Impact)**
Spreadsheet Tab Used	E.1) Impact pile driving	E.1) Impact pile driving
Source Level (Single Strike/shot SEL)	160	160*
Weighting Factor Adjustment (kHz)	2	2
a) Number of strikes in 1 h	1200	1400
a) Activity Duration (h) within 24-h period	5	5
Propagation (xLogR)	15	15
Distance of source level (meters)+	10	10
Other factors		Using Bubble Curtain*
*Attenuated value - Bubble curtain is assumed to provide 10dB of attenuation.		

Table 16. Distances to Levels A and B Harassment Threshold Criteria for Impact and Vibratory Pile Driving and Pile Removal

Parameters				Level B ZOI radii (meters)		Level A ZOI radii (meters)				
Pile Size and Type	**Drive Method**	**Piles per Day**	**Attenuation System**	**160 dB RMS**	**120 dB RMS**	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
H-Pile	Vibratory	6	None	NA	1,000	1	1	2	1	1
24 inch steel	Vibratory	4	None	NA	Calculated 10,000 Practical 2,000	13	1	19	8	1
36 inch steel	Vibratory	4	None	NA	Calculated 21,544 Practical 2,000	33	3	49	20	1
H-Pile	Impact	6	None	100	NA	33	1	39	18	1
24 inch steel	Impact	4	Bubble Curtain	215	NA	127	5	151	68	5
36 inch steel	Impact	4	Bubble Curtain	541	NA	243	9	290	130	9
24 inch concrete	Impact	5	None	46	NA	97	3	115	52	4
36 inch concrete	Impact	5	Bubble Curtain	117	NA	107	4	127	57	4
H-Pile	Proof Testing	2	None	100	NA	3	0	4	2	0
24 inch steel	Proof Testing	2	None	1,000	NA	46	2	55	25	2
36 inch steel	Proof Testing	2	None	2,512	NA	74	3	88	39	3

Sources: Sound levels from the Department's Compendium of Pile Driving Sound Data (Department 2007). Distances were calculated using the NMFS-provided companion User Spreadsheet, available at http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm.

The distance to the 120 dB RMS Level B ZOI threshold for vibratory pile driving was calculated to be 10,000 meters for 24-inch (0.61-meter) diameter steel pipe piles and 21,544 meters for 36-inch (0.91-meter) diameter steel pipe piles. Previous monitoring for the SFOBB Project has shown background sound levels in the active portions of the Bay, near the project area, to range from 110 to 140 dB RMS, with typical background levels in the range of 110 to 120 dB RMS (Department 2015). During previous hydroacoustic monitoring for the SFOBB Project, it has not been possible to detect or distinguish sound from vibratory pile driving beyond 1,000 to 2,000 meters (3,280 to 6,562 feet) from the source (Rodkin 2009). Under all previous IHAs for the SFOBB Project, which included vibratory pile driving, the ZOI for this activity has been set at 2,000 meters (6,562 feet) or less (NOAA 2016). Furthermore, it is not practical to monitor a zone over 2,000 meters (6,562 feet) and unlikely that marine mammals in the Bay will detect or show response to this sound at distances greater than 2,000 meters (6,562 feet), because of the background sound levels in the Central Bay. Therefore, the practical, applied ZOI for the vibratory driving of 24-inch (0.61-meter) and 36-inch (0.91-meter) diameter steel pipe piles has been set at 2,000 meters (6,562 feet), as shown in Table 16.

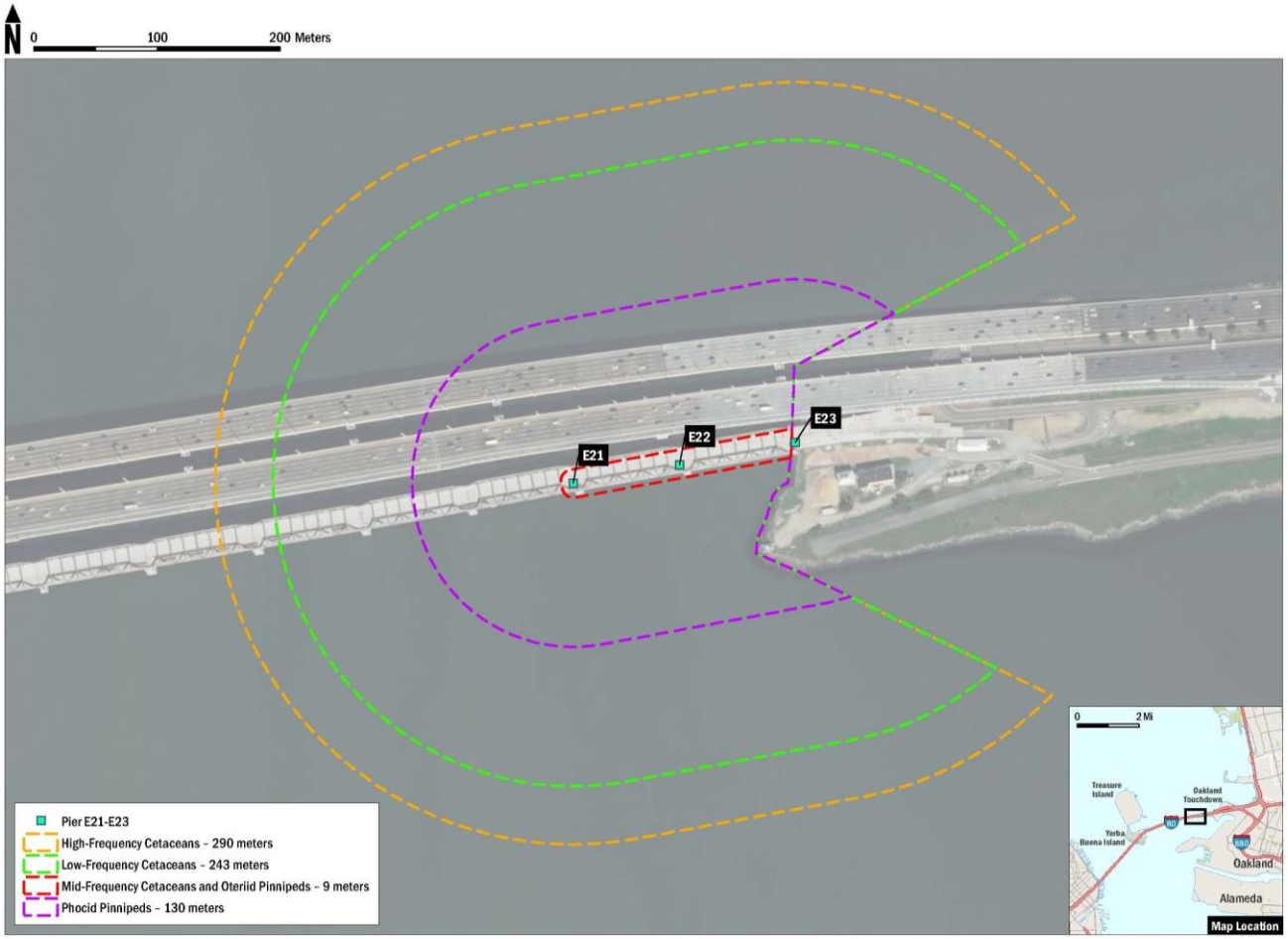
6.3.2. Number of Marine Mammals, by Species, that May be Taken by Pile Driving and Pile Removal Activities

The numbers of harbor seals, sea lions and harbor porpoise that may be taken by pile driving were calculated based on distance to the marine mammal threshold criteria, days of driving, and the estimated density of each species in the ZOI. The numbers of elephant seals, northern fur seals, bottlenose dolphin and gray whale that may be taken by pile driving were determined based on distance to the marine mammal threshold criteria, days of pile driving, and sightings and occurrence of these species in the Bay, specifically near the project area.

Because the sizes of piles, types of piles, or installation methods to be used are unknown at this time, the take estimate has been prepared based on a worst case scenario. The Level B take estimate is based on 60 days of pile driving to install 200 piles, 36 inches (0.91 meters) in diameter, with a vibratory hammer. The Level A take estimate is based on 60 days of pile driving to install 200 piles, 36 inches (0.91 meters) in diameter, with an impact hammer, using of an air bubble curtain sound attenuation system. The take of each species was calculated based on species density (Table 6), for the species that density could be determined, over the entire area of each threshold criteria zone as shown in Figures 14 and 15. The numbers used for take calculation are shown in Table 17.

Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 14. Marine Mammal Level B Vibratory Pile Driving Thresholds Distances



Source: ESRI 2015 (imagery); compiled by AECOM in 2018

Figure 15. Marine Mammal Level A Impact Pile Driving Thresholds Distances for 36-inch Piles

Table 17. Estimated Take of Marine Mammals from Pile Driving and Pile Removal Activities

Species	Species Density (animals/square kilometer)	Species Density (animals/square meters)	Level B ZOI radii (meters)	Level B ZOI Area (square meters)	Per Day Take Level B	Days of Pile Driving	Level B Take Calculated	Level B Take Requested
Harbor Seal	3.957	3.96E-06	2,000	9101027.61	36.0128	60	2160.7660	2161
Sea Lion	0.161	1.61E-07	2,000	9101027.61	1.4653	60	87.9159	88
Harbor Porpoise	0.167	1.67E-07	2,000	9101027.61	1.5199	60	91.1923	91
Bottlenose Dolphin	NA	NA	2,000	9101027.61	NA	60	NA	30
Elephant Seal	NA	NA	2,000	9101027.61	NA	60	NA	12
Gray Whale	NA	NA	2,000	9101027.61	NA	60	NA	4
Fur Seal	NA	NA	2,000	9101027.61	NA	60	NA	6
							Total Level B Take	2,392

Species	Species Density (animals/square kilometer)	Species Density (animals/square meters)	Level A ZOI radii (meters)	Level A ZOI Area (square meters)	Per Day Take Level A	Days of Pile Driving	Level A Take Calculated	Level A Take Requested[1]
Harbor Seal	3.957	3.96E-06	130	77907.73574	0.2101	60	18.4969	0
Sea Lion	0.161	1.61E-07	9	4302.570961	0.0000	60	0.0416	0
Harbor Porpoise	0.167	1.67E-07	290	293195.3612	0.0441	60	2.9378	0
Bottlenose Dolphin	NA	NA	9	4302.570961	NA	60	NA	0
Elephant Seal	NA	NA	130	77907.73574	NA	60	NA	0
Gray Whale	NA	NA	243	215669.2122	NA	60	NA	0
Fur Seal	NA	NA	9	4302.570961	NA	60	NA	0
							Total Level A Take[1]	0

Notes:

1. Impact pile driving will not begin if a marine mammal is within PTS, Level A, MMEZ. Therefore, no animals will be taken by Level A harassment.

Density Source: Table 6

ZOI Source: Table 15

The Department anticipates that a maximum of 2,392 animals may be taken by Level B harassment during pile-driving activities (Table 17). These animals will be exposed temporarily to continuous (vibratory pile driving and removal) sounds greater than 120 dB RMS and impulse (impact driving) sounds greater than 160 dB RMS. The majority of the animals taken by Level B harassment will be harbor seals (Table 17), the most numerous marine mammals in the project area. Although Level A take of harbor seals and harbor porpoise was calculated based on distances to the threshold, density of the species, and duration of the activity; the Department does not anticipate any individuals will be taken by Level A harassment. With proposed monitoring and establishment of MMEZs, discussed further in Chapter 11, "Mitigation Measures," Level A harassment of marine mammals will be avoided.

If a marine mammal is observed in a PTS MMEZ, pile driving will be delayed until the animal has moved out of the area or has not been observed for 15 minutes for pinnipeds and small cetaceans (harbor porpoise and bottlenose dolphin), and 30 minutes for gray whales. With implementation of the avoidance measures, exposure of marine mammals to sound levels that can result in PTS, Level A harassment will be avoided.

6.3.3. Species Impacts from Pile Driving Activates

Pacific Harbor Seal: Harbor seals are the most numerous marine mammal species in the SFOBB east span area. Based on estimated species density and distances compared to the Level B behavioral harassment threshold criteria, the Department anticipates a maximum of 2,161 harbor seals may be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving. With the proposed monitoring and establishment of the MMEZ, discussed in Chapter 11, slight injury, PTS Level A harassment will be avoided.

Many of the harbor seals observed during prior monitoring appeared to be transiting the area, but some remained in the area to forage (15 minutes to 2 hours). Seals observed foraging in the Level B harassment monitoring zone did not appear affected by activities. Although harbor seals may be present in the Level B harassment monitoring zone during pile driving, their exposure to sound generally will be for a short duration, and those seals that may remain to forage are expected to be unaffected.

Both juvenile and adult harbor seals were observed during prior monitoring. Establishing the gender of harbor seals in the water is difficult, unless the animal rolls over. However, both male and female harbor seals presumably have the potential to be present. Although

YBI is an important haul-out site in the Central Bay, it is not a pupping site. Pups are unlikely to be exposed to noise from pile driving.

Most of the observations of harbor seals made during monitoring for the SFOBB Project have been in the vicinity of YBI and the main navigation channel. Seals are less frequently observed in the shallow water areas near the Oakland shoreline, where pile driving is proposed.

Based on the known behavioral patterns, results of past monitoring, reduced sound levels, and implementation of avoidance and minimization measures (discussed further in Chapter 11), the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any harbor seals. Pile-driving activities may result in Level B behavioral harassment of both juvenile and adult harbor seals transiting or foraging in the project area.

California Sea Lion: Although less numerous than harbor seals, sea lions have been observed in the SFOBB east span area during previous monitoring. Based on estimated species density and distances compared to the Level B behavioral harassment threshold criteria, the Department anticipates a maximum of 88 sea lions may be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving. With the proposed monitoring and establishment of the MMEZ, discussed in Chapter 11, slight injury, PTS Level A harassment will be avoided.

Generally, during previous SFOBB Project pile-driving activities, sea lions were transiting only through the area and generally did not stop to forage, with a few exceptions. Although sea lions may enter the Level B behavioral harassment monitoring zone during pile-driving activities, the exposure to sound will be a short duration. Exposure to the pile driving sounds may cause a short-term behavior response, such as altering their travel path through the area, but is unlikely to affect their reproductive, foraging or hearing abilities.

Sub-adult and adult male sea lions can be distinguished from females by the sagittal crest on the head, but in the water, the gender of juveniles up to 3 years old is indistinguishable. During previous monitoring, sub-adult males, adult males, and juveniles (gender undistinguished) were observed. This is expected because female sea lions are less common in the Bay than males. Adult females remain near the rookeries in Southern California throughout the year, continuing to alternate between foraging and nursing their pups on shore until close to the next pupping/breeding season. After the breeding season, adult and sub-adult males migrate northward along the coast to Northern

California. Because of the gender and reproductive phase-specific distribution of animals, fewer females than males and no pups presumably will be affected by pile-driving activities.

Based on the known behavioral pattern of California sea lions, results of past monitoring, anticipated sound levels, and implementation of avoidance and minimization measures (discussed further in Chapter 11), the Department has determined that pile driving will not result in Level A harassment or mortality of California sea lions. Pile-driving activities may result in Level B harassment of a small number of adult male, sub-adult male, and juvenile sea lions that are transiting or foraging in the project area.

Northern Elephant Seal: Based on low number of elephant seal sightings in the project area , the Department anticipates that very few if any elephant seals would be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving.

Most of the elephant seals that have been observed around YBI or Treasure Island were stranded, sick, or injured animals, picked up by the MMC. No elephant seals have been observed in the immediate project vicinity. However, the number of elephant seals that may enter and or stand in the Bay in a given year is highly variable; dependent of changes in oceanographic conditions, effecting water temperature and prey availability. Further, the size of the Level B harassment zone is large, extending 2,000 meters (6,562 feet) from the pile driving site. Pile driving may take place for up to 60 days and many of the driving days would be consecutive. Should an elephant seal or multiple elephant seals be in the vicinity of the project area for multiple days they could be taken several times. The Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of 12 elephant seals by Level B harassment during pile driving activities (Table 17). This equates to the take of one elephant seal during 20% of the driving days.

Based on the known behavioral patterns, results of past monitoring, anticipated sound levels, and the implementation of avoidance and minimization measures, including the establishment and monitoring of the MMEZ (discussed further in Chapter 11), the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any elephant seals.

Northern Fur Seal: Based on the low number of fur seals and distances to the Level B behavioral harassment threshold criteria, the Department anticipates very few if any

northern fur seals will be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving.

Most of the fur seals that have been observed around in the Bay were stranded, sick, or injured animals, picked up by TMMC. No fur seals have been observed in the immediate project vicinity. However, the number of fur seals that may enter and or strand in the Bay in a given year is highly variable; dependent on changes in oceanographic conditions, effecting water temperature and prey availability. Further, the size of the Level B harassment zone is large, extending 2,000 meters (6,562 feet) from the pile driving site. Pile driving may take place for up to 60 days and many of the driving days would be consecutive. Should a fur seal or multiple fur seals be in the vicinity of the project area for multiple days they could be taken several times. The Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of up to six northern fur seals by Level B harassment during pile driving activities (Table 17). This equates to the take of one elephant seal during 10% of the driving days.

Based on the known behavioral patterns, results of past monitoring, anticipated sound levels, and the implementation of avoidance and minimization measures, including the establishment and monitoring of the MMEZ (discussed further in Chapter 11), the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any fur seals.

Harbor Porpoise: Based on estimated species density and distances to the Level B behavioral harassment threshold criteria, the Department anticipates a maximum of 91 harbor porpoises may be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving. With the proposed monitoring and establishment of the MMEZ, discussed further in Chapter 11, slight injury, PTS Level A harassment will be avoided.

Most harbor porpoises reported during previous monitoring were observed at distances ranging from 2,438 to 3,048 meters (8,000 to 10,000 feet) from the work area. Although harbor porpoises may be present in the Level B harassment monitoring zone during pile driving, the exposure to sound generally will be for a short duration, and thus they are expected to be unaffected.

Both juvenile and adult harbor porpoises were observed during previous monitoring. Establishing the gender of harbor porpoises in the water is difficult. However, both male and female harbor porpoises presumably will have the potential to be present.

Based on the known behavioral patterns, results of past monitoring, reduced sound levels, and implementation of avoidance and minimization measures (discussed further in Chapter 11), the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any harbor porpoises. Pile-driving activities may result in Level B behavioral harassment of a small number of both juvenile and adult harbor porpoises transiting or foraging in the project area.

Bottlenose Dolphin: Only small numbers of bottlenose dolphin occur in the project vicinity. As discussed in Chapter 4, until 2016, most bottlenose dolphins in the Bay were observed in the western Bay, from the Golden Gate Bridge to Oyster Point and Redwood City, although one individual was observed frequently near the former Alameda Air Station (Perlman 2017). As of 2017, the same two individuals have been observed regularly near Alameda (Keener, pers. comm., 2017) are likely pass by the project area. If additional individuals begin using this eastern area of the Bay, the number of bottlenose dolphin sightings near the project area will likely increase. The Department wants to ensure that the project has coverage for the incidental take of any species with the potential to be present in the project area. It is possible that the same two resident bottlenose dolphins and or additional individuals could be taken multiple times during the up to 60 days of pile driving. Therefore, the Department is requesting authorization for the take of 90 bottlenose dolphins by Level B harassment during pile driving activities. This equates to the take of 1.5 bottlenose dolphins during each day of pile driving.

Based on the known behavioral patterns, small numbers, results of past monitoring, reduced sound levels, and implementation of avoidance and minimization measures, including the establishment and monitoring of the MMEZ (discussed further in Chapter 11), the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any bottlenose dolphins.

Gray Whale: Based on the low number and infrequent occurrence of this species near the project area and distances to the Level B behavioral harassment threshold criteria, the Department anticipates that no gray whales will be exposed to continuous sounds greater than 120 dB RMS and impulse sounds greater than 160 dB RMS during pile driving.

No gray whales have been observed within 2,000 meters (6,562 feet) of the project area, but they have been observed just north of Treasure Island and southwest of Oakland Middle Harbor. According to TMMC, two to six gray whales enter the Bay each year in late winter through spring (February through April), presumably to feed. The Department wants to ensure that the project has coverage for the incidental take of any species with

the potential to be present in the project area. Therefore, the Department is requesting authorization for the take of 4 grey whales by Level B harassment during pile driving activities.

Based on the known behavioral patterns, results of past monitoring, anticipated sound levels, and implementation of avoidance and minimization measures (discussed further in Chapter 11, the Department has determined that the pile-driving activities will not result in Level A harassment or mortality to any gray whales. Furthermore, pile-driving activities are not anticipated to result in Level B behavioral harassment of gray whales. However, in the unlikely event that a gray whale or calf cow pair transit or forage in the project area during pile-driving activities, the Department is requesting authorization for the take of up to four individuals.

6.4. Combined Take Requested for Pier Implosion and Pile-Driving Activities

Table 18 summarizes the combined take requested for pier implosion and pile-driving activities.

Table 18. Combined Total Take Requested for Pier Implosion and Pile-Driving Activities

Species	Pier Implosion Level B Harassment Take[1]		Pile Driving Level B Harassment Take[1]	Total Level B Harassment Take[1]
	Behavioral Response	Temporary Threshold Shift		
Pacific Harbor Seal	20	10	2,161	2,191
California Sea Lion	4	3	88	95
Northern Elephant Seal	2	1	12	15
Northern Fur Seal	2	1	6	9
Harbor Porpoise	10	8	91	109
Bottlenose Dolphin	4	2	30	36
Gray Whale	0	0	4	4

Note:

1. Pier implosion, pile driving, and test blasts will be delayed if any marine mammals are detected within any of the Level A or mortality threshold criteria exclusion zones.

Pile Driving Level B Harassment Take Request Source: Table 17

Pier Implosion Level B Harassment Take Request Source: Developed by AECOM in 2017

Chapter 7. The Anticipated Impact of the Activity

The numbers shown in Tables 9 to 11 (for pier implosion) and Table 16 (for pile driving) represent estimated exposures to each harassment threshold criteria under the MMPA. The threshold zones for pier implosion and pile driving were calculated based on measurements collected during previous SFOBB Project pier implosions and previous pile-driving activities.

Because of this analysis and through implementation of avoidance and minimization measures, the Department has determined that the proposed controlled implosions and pile driving will result only in Level B harassment. Based on the best available science, exposures to marine mammal species and stocks from controlled implosions and pile driving is anticipated to result in only short-term effects on individuals exposed, will not be likely to affect annual rates of recruitment or survival, and implemented mitigation measures will prevent any Level A exposures or mortality.

Based on 17 years of previous project construction and demolition activities associated with the SFOBB east span and the protective measures described herein, no permanent injury or mortality will occur to animals, and no impacts (short or long term) will occur on the populations or stocks of marine mammals that regularly inhabit or occasionally enter the Bay.

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Chapter 8. The Anticipated Impacts on Subsistence Uses

Not applicable; none of the species or stocks of marine mammals regularly found in the Bay are used for subsistence.

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Chapter 9. The Anticipated Impacts on Habitat

No designated critical habitat exists for marine mammals in the Bay. The primary source of effects on marine mammal habitat will be temporary noise and pressure exposures from controlled blasting and pile driving, as well as isolated changes in water quality. The SFOBB Project is not expected to have any substantial effects on marine mammal habitat. Short-term impacts on water clarity may result from minimal disturbance of sediment during pier implosions, pile driving, and from cleanup of debris from the pier implosions.

The removal of the SFOBB east span is not likely to negatively affect the habitat of marine mammal populations because no permanent loss of habitat will occur, and only a minor, temporary modification of habitat will occur. The project area is not used as a haul-out site by pinnipeds or as a major foraging area. Demolition of the concrete marine foundations is unlikely to permanently decrease fish populations in the area and is unlikely to affect marine mammal populations.

Project activities will not affect any pinniped haul-out sites or pupping sites. The YBI harbor seal haul-out site is on the opposite side of the island from the project area. Because of the distance and the island blocking the sound, underwater noise and pressure levels from the SFOBB Project will not reach the haul-out site. During previous monitoring efforts, the airborne pile-driving noise could be heard faintly, on occasion, by the monitors at the YBI haul-out site, or when the sound reflected off passing cargo ships. In addition, harbor seals on YBI commonly are subjected to high levels of disturbance, primarily from watercraft, ship wakes, traffic noise, and the BART Transbay Tube. This is particularly true during the summer, when the numbers of small recreational watercraft in the Bay increase (Green et al. 2002). Other haul-out sites for sea lions and harbor seals are at a sufficient distance from the project area that they will not be affected. The closest recognized harbor seal pupping site is at Castro Rocks, approximately 14 kilometers (8.7 miles) from the project area. No sea lion rookeries are found in the Bay.

The addition of underwater sound from project activities to background noise levels can constitute a potential cumulative impact on marine mammals. However, these potential cumulative noise impacts will be short in duration, and presumably they will be negligible because of the high background noise in the Bay from other anthropogenic sources. During breaks in previous pile driving, the Department's hydroacoustic monitors took background noise measurements of the Bay near the project area. The measurements indicated that background levels range from about 110 to 140 dB RMS, but more

typically range from 110 to 120 dB RMS (Department 2005). Boat traffic, including cargo ships, powerboats, and tugboats that use the shipping channel south of the project area, as well as the BART Transbay Tube contribute to background noise levels.

SPLs from pier implosion and impact pile driving have the potential to injure or kill fish in the immediate area. During previous pile driving and pier implosions, the Department has reported mortality to marine mammal prey species, including northern anchovies and Pacific herring. These few isolated fish mortality events are not anticipated to have a substantial effect on prey species populations or their availability as a food resource for marine mammals.

Based on the discussion in this chapter, no effects on marine mammals will occur from loss or modification of marine mammal habitat, including changes to food resources or haul-out habitat.

Chapter 10. Anticipated Effects of Habitat Impacts on Marine Mammals

The removal of piers through controlled implosions and pile driving are not likely to negatively affect the habitat of marine mammal populations because no loss of habitat will occur, and only a minor, temporary modification of habitat will occur from the hydroacoustic impacts of the controlled implosions and pile driving. The project area is not used as a haul-out site by pinnipeds, and demolition of the concrete marine foundations is unlikely to permanently decrease fish populations. The physical effects from pressure waves that are generated by underwater impulse sounds (e.g., underwater implosions and impact pile driving) may result in minor injury and mortality to fish but will not affect fish populations within proximity of project activities. The abundance and distribution of fish in the immediate vicinity of imploded bridge piers and impact pile-driving activities may be altered for a few hours during and immediately following the activities. These fish populations will be replenished as project activities cease and the local population mixes again.

Based on the discussions above and in Chapter 9, no impacts will occur on marine mammals, resulting from loss or modification of marine mammal habitat. No designated critical habitat occurs in the Bay. The SFOBB Project is not expected to result in loss of marine mammal habitat (i.e., no destruction of haul-out sites or destruction of reef areas will occur). Therefore, no impacts will occur.

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Chapter 11. Mitigation Measures

11.1. Minimization of Impacts from Implosion of Piers E19 and E20

The methods proposed to demolish Piers E19 and E20 will provide the least impact on marine mammal stocks and their habitat. A BAS will be used for all controlled implosions. The use of controlled charges for demolition will decrease the cumulative amount of marine habitat affected and the effects on individual marine mammals within this habitat that are exposed to potentially harmful SPLs.

An analysis of the potential effects on marine mammals from the alternative use of traditional cofferdam methods to remove Pier E3 was completed (see Appendix B). In summary, the analysis concluded that the cumulative area subject to Level B behavioral harassment will be much greater for traditional removal methods using a dewatered cofferdam because of the increased time required for the impact driving of the large number of piles needed to construct a dewatered cofferdam around the pier, capable of holding back the Bay waters. The traditional cofferdam methods for removal of Piers E19 and E20 are similar to those analyzed for Pier E3, and would result in a similar impact on marine mammals. The actual risk of Level A harassment exposure to individual marine mammals from either demolition method is low, because implementation of exclusion zones and monitoring will occur.

The decision to combine two smaller piers into single, sequential blast events will further reduce potential impacts on marine mammals. This will allow faster completion of the project and will reduce the total number of pier implosion events (days where pier implosions occur). In addition, the total area (ZOI) affected by elevated SPLs from pier implosions will be reduced, because of the overlap in ZOI from the sequential implosions of adjacent piers as opposed to the cumulative area affected by implosions of all piers individually.

11.1.1. Blast Attenuation System

As described previously in this document, a BAS will be used around both piers during the implosion. Based on the results of acoustic monitoring for the previous pier implosions, BAS performance is anticipated to provide approximately 70 to 80 percent attenuation of implosion-related pressure waves.

11.1.2. Monitoring Plan and Establishment of Marine Mammal Exclusion Zones

During the implosion of Piers E19 and E20, a project-specific monitoring plan (discussed further in Chapter 13, "Monitoring and Reporting") will be implemented to avoid the potential for individual exposure to Level A harassment, and to document the number and species potentially exposed to Level B harassment. This plan will be similar to the Marine Foundation Removal Project Final Biological Monitoring Program, previously approved by NMFS, that was implemented during the implosions of Piers E6 to E18. In particular, monitors will observe the MMEZ and will delay the implosion if any individuals are within this zone. As discussed in Chapter 6, the implosion will not proceed until the individual leaves the MMEZ or at least 15 minutes have passed since the last observation. The same procedure was implemented successfully for the implosions of Piers E3 through E18, and no marine mammals were exposed to SPLs above the Level A or mortality threshold criteria. This project-specific monitoring plan will be transmitted to NMFS before the implosions, for review and concurrence.

11.2. Minimization of Impacts from Pile Driving

To minimize potential impacts on marine mammals, the Department will limit both the size of piles and duration of impact pile driving, to the extent feasible. Larger piles are expected to generate higher SPLs than smaller piles. Limiting the size of piles to 36 inches (0.91 meter) in diameter or smaller will minimize potential noise impacts.

All steel pipe piles will be installed with either a vibratory hammer or impact hammer. The vibratory hammer may be used to drive the majority of the total pile lengths. In the event that a pipe pile is installed entirely with a vibratory hammer, it still will be subject to final proof testing with an impact hammer. A maximum of 10 percent of the piles installed completely with a vibratory hammer may be proof-tested with an impact hammer, without the use of a marine pile-driving energy attenuator. Proofing of piles will be limited to a maximum of two piles per day, for less than 1 minute per pile, administering a maximum of 20 blows per pile. Although both vibratory and impact pile driving have the potential to affect marine mammals, impact driving is expected to generate higher SPLs. Requiring the use of the vibratory hammer will reduce the duration of impact driving and potential exposure to higher SPLs.

11.2.1. Marine Pile Driving Energy Attenuator Air Bubble Curtain System

Use of a marine pile-driving energy attenuator (i.e., air bubble curtain system), or other equally effective sound attenuation method (e.g., dewatered cofferdam), will be required during impact driving of all steel pipe piles (with the exception of pile proof-testing) and

during impact driving of 0.91-meter (36-inch) diameter concrete piles. Requiring the use of sound attenuation will reduce SPLs and the size of the ZOIs for Level A and Level B harassment.

11.2.2. Monitoring Plan and Establishment of Marine Mammal Exclusion Zones for Pile-Driving Activities

A project-specific marine mammal monitoring plan for pile-driving activities (discussed further in Chapter 13) will be employed, to avoid the potential for individual exposure to Level A harassment, and to document the number and species potentially exposed to Level B harassment. The plan will be similar to the previously NMFS-approved, 2013 Revised Marine Mammal Monitoring Plan (Department 2013d) for SFOBB Project pile-driving activities. Before the start of impact pile-driving activities (with the exception of pile proof-testing), the MMEZs will be established. The MMEZs are intended to include all areas where the underwater SPLs are anticipated to equal or exceed thresholds for slight injury—PTS Level A harassment thresholds for the specific species hearing groups, shown in Table 4. NMFS-approved observers will survey the MMEZs before pile-driving activities start. If marine mammals are found within the MMEZ, pile driving will be delayed until the animal has moved out of the exclusion zone, either verified through sighting by an observer or by waiting until enough time has elapsed without a sighting, 15 minutes for pinnipeds and small cetaceans (harbor porpoise and bottlenose dolphin), and 30 minutes for gray whale, to be able to assume that the animal has moved beyond the MMEZ. With implementation of this avoidance and minimization measure, exposure of marine mammals to SPLs that can result in PTS Level A harassment will be avoided.

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Chapter 12. Arctic Plan of Cooperation

Not applicable; no activities will occur within Arctic subsistence hunting areas.

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Chapter 13. Monitoring and Reporting

A specific marine mammal monitoring plan for implosion of Piers E19 and E20 and pile driving will be developed and employed, to avoid the potential Level A harassment of marine mammals and document the number individuals by species taken by Level B harassment.

13.1. Monitoring Plan for Implosion of Piers E19 and E20

The marine mammal monitoring plan for implosion of Piers E19 and E20 will be similar to the NMFS-approved marine mammal monitoring plans that were implemented for the implosions of Piers E3 to E18. The monitoring plan will include Level A injury exclusion zones and Level B TTS and behavioral response harassment monitoring zones extending out to a pre-determined distance from piers, based on conservatively estimated distances to acoustic threshold criteria.

The following are the general elements of the plan; a detailed monitoring plan will be developed (in cooperation with NMFS) that will include all monitoring requirements and final conditions of the IHA.

Level A Harassment Injury and Mortality Exclusion Zones: The MMEZs will include the area for both the mortality and Level A harassment thresholds (i.e., PTS, GI track injury, and slight lung injury), using the criteria threshold that extends out the furthest. Hydroacoustic monitoring results from the previous pier implosions were used to calculate distances to these thresholds for the implosion of Piers E19 and E20, as discussed in Chapter 6 and shown in Tables 7 and 8.

The isopleths for PTS to phocid pinnipeds (harbor seal and elephant seal) cover the entire area for both Level A harassment and mortality for all pinnipeds, including otariid pinnipeds (sea lion and fur seal), as well as bottlenose dolphin, that have smaller zones for Level A harassment. Therefore, the pinniped and dolphin exclusion zone will be established at the radial distance to the phocid pinniped PTS Level A harassment threshold (Table 19). The harbor porpoise exclusion zone will be established at the radial distance to the high-frequency cetacean PTS Level A harassment threshold (Table 19).

The MMEZs will be monitored by MMOs, and if any marine mammals are observed within the MMEZs, the implosion will be delayed until the animal leaves the area or at least 15 minutes have passed since the last observation of the animal.

Level B Harassment Behavioral Response and TTS Monitoring Zones: Marine mammal monitoring zones will be established for both Level B behavioral response and Level B TTS. Hydroacoustic monitoring results from the previous implosions were used to calculate distances to these thresholds for the implosion of Piers E19 and E20, as discussed in Chapter 6 and shown in Tables 7 and 8.

The isopleths for Level B harassment to phocid pinnipeds (harbor seal and elephant seal) cover the entire area for Level B harassment to all pinnipeds, including otariid pinnipeds (sea lion and fur seal), as well as bottlenose dolphin, that have smaller zones for Level B harassment. Therefore, the pinniped and dolphin Level B harassment monitoring zones, for each pier implosion scenario, will be established at the radial distance to the phocid pinniped Level B behavioral harassment threshold (Table 19).

The harbor porpoise Level B harassment monitoring zone will be established at the radial distance to the high-frequency cetacean Level B behavioral harassment thresholds for behavioral response and TTS (Table 19).

Table 19. Marine Mammal Level A Exclusion Zones and Level B Monitoring Zones for the Implosion of Piers E19 and E20

Species / Group	Level B Behavioral Response Monitoring Zone	Level B TTS Monitoring Zone	Level A Injury and Mortality Exclusion Zone
Pinniped and Dolphin	290 meters (951 feet)	200 meters (656 feet)	70 meters (230 feet)
Harbor Porpoise	1,220 meters (4,003 feet)	830 meters (2,723 feet)	290 meters (951 feet)
Source: Table 7			

Marine Mammal Observers: A minimum of eight MMOs will be required during the implosion of Piers E19 and E20, so that the MMEZs and Level B harassment zones can be monitored. One MMO will be designated as the Lead MMO, who will receive updates from other MMOs on the presence or absence of marine mammals within the MMEZ. This Lead MMO will notify the Environmental Compliance Manager of a cleared MMEZ before the start of the implosion(s).

Monitoring Protocol: Pier implosions will be conducted only during daylight hours and with enough time for pre- and post-implosion monitoring, and with good weather (i.e.,

clear skies and no high winds). Project activities will be completed so that the MMOs will be able to detect marine mammals within the MMEZs and beyond. The Lead MMO will be in contact with other MMOs. If any marine mammal enters a MMEZ within 30 minutes of blasting, the Lead MMO will notify the Environmental Compliance Manager to inform that the implosion may need to be delayed. The Lead MMO will keep the Environmental Compliance Manager informed about the disposition of the animal. If the animal remains in the MMEZ, blasting will be delayed until it has left the MMEZ. If the animal dives and is not seen again, blasting will be delayed at least 15 minutes. After the implosion has occurred, the MMOs will continue to monitor the area for at least 60 minutes.

Although any injury or mortality from the pier implosions is very unlikely, boat or shore surveys will be conducted for 2 days following each event, to determine whether any injured or stranded marine mammals are in the area. If an injured or dead animal is discovered during these surveys or by other means, the NMFS-designated stranding team will be contacted to pick up the animal. Veterinarians will treat the animal or will conduct a necropsy to attempt to determine whether it stranded because of the pier implosions.

Data Collection: Each MMO will record the observation position, start and end times of observations, and weather conditions (i.e., sunny/cloudy, wind speed, fog, visibility). For each marine mammal sighting, the following will be recorded, if possible:

1. Species
2. Number of animals (with or without pup/calf)
3. Age class (pup/calf, juvenile, adult)
4. Identifying marks or color (e.g., scars, red pelage, damaged dorsal fin)
5. Position relative to pier implosion (distance and direction)
6. Movement (direction and relative speed)
7. Behavior (e.g., logging [resting at the surface], swimming, spy-hopping [raising above the water surface to view the area], foraging)
8. Duration of sighting or times of multiple sightings of the same individual

Communication: All MMOs will be equipped with a radio and mobile phone as a backup. One channel will be dedicated to the MMOs. One person will be designated as the Lead MMO and will be in constant contact with the Environmental Compliance

Manager. The Lead MMO will coordinate marine mammal sightings with the other MMOs. The Lead MMO will contact other MMOs when a sighting is made within the MMEZ or near the MMEZ, so that the MMOs within overlapping areas of responsibility can continue to track the animal and the Lead MMO is aware of the animal. If it is within 30 minutes of blasting and an animal has entered the MMEZ or is near it, the Lead MMO will notify the Environmental Compliance Manager, who will be kept informed of the disposition of the animal.

13.1.1. Test Blast

SPLs from test blasts will not reach or exceed thresholds for harassment of marine mammals, beyond the bubble flux of the BAS. As previously discussed, it will not be possible for a marine mammal to swim through the bubble flux and be exposed to near-field SPLs. Therefore, test blasts will not result in take of marine mammals. As a conservative measure, one MMO will be on-site during all test blasts, to monitor the movement and response of marine mammals in the area.

13.1.2. Stranding Plan

A stranding plan for the pier implosions has been prepared in cooperation with the local NMFS-designated marine mammal stranding, rescue, and rehabilitation center. An updated version of this plan will be implemented during the implosion of Piers E19 and E20. Although avoidance and minimization measures are likely to prevent any injuries, preparations will be made in the unlikely event that marine mammals are injured. Elements of that plan will include the following:

1. The stranding crew will prepare treatment areas at an NMFS-designated facility for cetaceans or pinnipeds that may be injured from the implosions. Preparation will include equipment to treat lung injuries, auditory testing equipment, dry and wet caged areas to hold animals, and operating rooms if surgical procedures are necessary.

2. A stranding crew and a veterinarian will be on call near the project area at the time of the implosions, to quickly recover any injured marine mammals, provide emergency veterinary care, stabilize the animal's condition, and transport individuals to an NMFS-designated facility. If an injured or dead animal is found, NMFS (both the regional office and headquarters) will be notified immediately, even if the animal appears to be sick or injured from causes other than the implosions.

3. Post-implosion surveys will be conducted immediately after the event and over the following 2 days to determine whether any injured or dead marine mammals are in the area.

4. Any veterinarian procedures, euthanasia, rehabilitation decisions, and time of release or disposition of the animal will be at the discretion of the NMFS-designated facility staff and the veterinarians treating the animals. Any necropsies to determine whether the injuries or death of an animal were the result of an implosion or other anthropogenic or natural causes will be conducted at an NMFS-designated facility by the stranding crew and veterinarians. The results will be communicated to both the Department and NMFS as soon as possible, followed by a written report within a month.

13.2. Monitoring Plan for Pile Driving

The marine mammal monitoring plan for pile-driving activities will be similar to the NMFS-approved 2013 Revised Marine Mammal Monitoring Plan for the SFOBB Project (Department 2013d). The monitoring plan will include Level A injury exclusion zones and Level B TTS and behavioral response harassment monitoring zones extending out to a pre-determined distance from the pile-driving activity, based on conservatively estimated distances to acoustic threshold criteria.

The following are the general elements of the plan; a detailed monitoring plan will be developed (in cooperation with NMFS) that includes all monitoring requirements and final conditions of the IHA.

Level A Harassment PTS Exclusion Zone: The MMEZs will include all areas where the underwater SPLs are anticipated to equal or exceed thresholds for Level A harassment PTS thresholds, shown in Table 5. Before impact or vibratory pile driving or pile removal (with the exception of pile proof-testing), initial MMEZs will be established at a radial distance, as shown in Table 19. After impact pile driving begins, hydroacoustic measurements will be collected for the specific activity (location and size/type of pile). These hydroacoustic monitoring results will be provided to NMFS, and the radius of the exclusion zone will be adjusted, based on measured SPLs. The MMEZs will be monitored by MMOs, and if any marine mammals are observed inside the MMEZs, impact pile driving will be delayed until the animal leaves the area or at least 15 minutes have passed since the last observation of a pinniped or small cetacean (harbor porpoise and bottlenose dolphin), and at least 30 minutes have passed since the last observation of a gray whale.

Level B Behavioral Harassment Monitoring Zones: Behavioral harassment monitoring zones will include areas where the underwater SPLs are anticipated to equal or exceed thresholds for Level B behavioral response and TTS: 160 dB RMS for impulse sounds (impact pile driving), and 120 dB RMS for continuous sounds (vibratory pile driving and removal), for all species.

Before impact or vibratory pile driving or pile removal (with the exception of pile proof-testing), initial Level B marine mammal monitoring zones will be established at the radial distance shown in Table 27. After the pile driving activity begins, hydroacoustic measurements will be collected for the specific activity (location and size/type of pile). These hydroacoustic monitoring results will be provided to NMFS, and the radius of the Level B monitoring zone will be adjusted, based on measured SPLs.

Marine Mammal Monitoring during Pile Driving: The MMEZs will be monitored during all vibratory pile driving and impact pile driving (attenuated or unattenuated), except pile proof-testing. The Level B harassment zone will be monitored during all vibratory pile driving and impact pile-driving (attenuated or unattenuated), except pile proof-testing. The Department will not perform marine mammal monitoring during the unattenuated pile proof-testing, because the proofing of a pipe pile will require less than 1 minute of impact driving per pile, with a maximum of two piles per day. The logistics of scheduling and mobilizing a monitoring team for activities that will last less than 2 minutes per day is not practical.

Monitoring of the MMEZs and Level B harassment zones during in-water pile driving will be conducted by a minimum of three NMFS-approved MMOs. The MMOs will begin monitoring at least 30 minutes before the start of the pile-driving/removal activities. The MMOs likely will conduct the monitoring from small boats, bridge piers, YBI and/or Treasure Island, the new SFOBB bike path, or construction barges. The number and distribution of observers will be dependent on the construction site (taking into account barges, bridge piers, or other visual obstructions in the area) and the size of the MMEZs or Level B harassment zones.

If any marine mammals are observed inside the MMEZs before the start of impact pile driving, that activity will be delayed until the animal leaves the area or at least 15 minutes have passed since the last observation of a pinniped or small cetacean (harbor porpoises and bottlenose dolphin), or 30 minutes for gray whales. If a marine mammal is sighted inside the MMEZ after pile driving has begun, pile driving will be shut-down. Pile driving may resume after the animal has moved out of the MMEZ or at least15 minutes have

passed since the last observation of a pinniped or small cetacean (harbor porpoises and bottlenose dolphin) or 30 minutes for gray whales.

Table 20. Marine Mammal Level A Exclusion Zones and Level B Monitoring Zones for Pile-Driving Activities

Pile Type	Installation Method	Attenuation System	Level A Pinniped and Dolphin Exclusion Zone	Level A Porpoise and Whale Exclusion Zone	Level B Monitoring Zone All Species
H-Pile	Vibratory	None	2 meters (7 feet)	1 meter (3 feet)	1,000 meters (3,280 feet)
24-inch Steel Pipe Pile	Vibratory	None	8 meters (26 feet)	19 meters (62 feet)	2,000 meters (6,562 feet)
36-inch Steel Pipe Pile	Vibratory	None	20 meters (98 feet)	49 meters (161 feet)	2,000 meters (6,562 feet)
H-Pile	Impact	None	18 meters (59 feet)	39 meters (128 feet)	100 meters (328 feet)
24-inch Steel Pipe Pile	Impact	Bubble Curtain	68 meters (223 feet)	151 meters (495 feet)	215 meters (705 feet)
36-inch Steel Pipe Pile	Impact	Bubble Curtain	130 meters (427 feet)	290 meters (951 feet)	541 meters (1,775 feet)
24-inch Concrete Pile	Impact	None	52 meters (171 feet)	115 meters (377 feet)	46 meters (151 feet)
36-inch Concrete Pile	Impact	Bubble Curtain	57 meters (187 feet)	127 meters (417 feet)	117 meters (384 feet)

Source: Table 16

Observations will be made using binoculars during daylight hours. Each member of the monitoring team will be equipped with a radio and mobile phone as a backup for contact with the Lead MMO and other MMOs. The Lead MMO will be positioned on the pile-driving barge to warn the construction crew if any marine mammals are sighted in the MMEZ.

Data on all observations will be recorded in waterproof notebooks. For each marine mammal sighting, the following will be recorded, if possible:

1. Species
2. Number of animals (with or without pup/calf)
3. Age class (pup/calf, juvenile, adult)
4. Identifying marks or color (e.g., scars, red pelage, damaged dorsal fin)
5. Position relative to pile driving (distance and direction)
6. Movement (direction and relative speed)
7. Behavior (e.g., logging [resting at the surface], swimming, spy-hopping [raising above the water surface to view the area], foraging)
8. Duration of sighting or times of multiple sightings of the same individual

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Chapter 14. Suggested Means of Coordination

Data gathered to date during the SFOBB Project has provided valuable information on the underwater SPLs generated by pile driving, mechanical dismantling, and underwater explosives. Results from both marine mammal and hydroacoustic monitoring have been provided to NMFS and other regulatory resource agencies. In addition, the Department has provided recordings of pile driving to NMFS for its own analysis.

Hydroacoustic monitors for the SFOBB Project have independently published monitoring results, used data from the project in developing a *Compendium of Pile Driving Sound Data* (Department 2007) for the Department, and served as technical experts to the Fisheries and Hydroacoustic Working Group.

The SFOBB Project team has coordinated with and worked closely with the local marine mammal stranding, rescue, and rehabilitation center. TMMC has provided annual data on marine mammal strandings in the Bay, to inform the analysis of potential takes from project activities. The team also has worked in partnership with TMMC in development and implementation of the post-blast marine mammal stranding plan and surveys.

Marine mammal monitors for the SFOBB Project have close ties with TMMC, Long Marine Laboratory (University of California, Santa Cruz), and Moss Landing Marine Laboratory, and have assisted in population and radio telemetry studies in the Bay.

The use of highly controlled explosives to demolish underwater marine foundations is a fairly new construction method, which has not been well studied. The Department has implemented a robust biological monitoring program for marine foundation removal, including marine mammal, hydroacoustic, avian, fish, and water quality monitoring. The results of this monitoring have demonstrated this to be a highly effective construction method with negligible impact on environmental and biological resources.

The IHA applications for the SFOBB Project, as well as the monitoring program (monitoring methods) and results have been shared with regulators and are publicly available for review by others who may be planning similar projects that will require analysis of potential effects and development of biological monitoring programs.

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Chapter 16. References

Allen, B. M., and R. P. Angliss. 2013. *Alaska Marine Mammal Stock Assessments, 2012*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-245.

———. 2014. *Alaska Marine Mammal Stock Assessments, 2013*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-277.

———. 2015. *Alaska Marine Mammal Stock Assessments, 2015*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-323.

Allen, S.G., D.G. Ainley, G.W. Page, and C.A. Ribic. 1984. The Effect of Disturbance on Harbor Seal Haul-out Patterns at Bolinas Lagoon, California. *Fisheries Bulletin*. 82:493–499.

Andersen, S. 1970. Auditory Sensitivity of the Harbour Porpoise *Phocoena phocoena*. Investigations of Cetacean. 2:255-259.

Antonelis, G. A., B. S. Stewart, and W. F. Perryman. 1990. Foraging Characteristics of Female Northern Fur Seals (*Callorhinus ursinus*) and California Sea Lions (*Zalophus californianus*). *Canadian Journal of Zoology* 68:150–158.

Au, W. 1993. *The Sonar of Dolphins*. New York, NY: Springer–Verlag.

Barlow, J. P. 2015. Inferring Trackline Detection Probabilities, g(0), for Cetaceans from Apparent Densities in Different Survey Conditions. *Marine Mammal Science* 31(3):923–943.

———. 2016. *Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991-2014*. NOAA Southwest Fisheries Science Center, Administrative Report LJ-16-01.

Barlow, J. P., and D. Hanan. 1995. An Assessment of the Status of Harbor Porpoise in Central California. *Reports of the International Whaling Commission,* Special Issue 16:123–140.

Blackwell, S. B., J. W. Lawson, and M. T. Williams. 2004. Tolerance by Ringed Seals (*Phoca hispida*) to Impact Pipe-Driving and Construction Sounds at an Oil Production Island. *Journal of the Acoustical Society of America* 115:2346–2357.

Braham, H. W. 1984. Distribution and Migration of Gray Whales in Alaska. In *The Gray Whale*, M. L. Jones, S. L. Swartz, and S. Leatherwood (editors), 249–266. London: Academic Press.

California Department of Transportation (Department). 2001. *Pile Installation Demonstration Project Marine Mammal Impact Assessment.* Prepared by URS Corporation and Parsons Brinckerhoff.

———. 2004b. *Marine Mammal and Acoustic Monitoring for the Eastbound Structure*. Prepared by SRS Technologies, Illingworth & Rodkin, and Parsons Brinckerhoff.

———. 2005. *San Francisco–Oakland Bay Bridge East Span Seismic Safety Project, Hydroacoustic Monitoring Report.* Prepared by Illingworth & Rodkin, Inc.

———. 2007. *Compendium of Pile Driving Sound Data.* Prepared by Illingworth & Rodkin, Inc.

———. 2013a (November 4). *Advanced Planning Study: San Francisco–Oakland Bay Bridge Pier E3 Demonstration Program.*

———. 2013b. *Summary of Marine Mammal Monitoring during Demolition of Foundation C3, October 8–9, 2013*. Prepared by Garcia and Associates.

———. 2013c. *Summary of Marine Mammal Monitoring during Driving of Temporary Piles for the Tower 1 Fenders, 2013*. Prepared by Garcia and Associates.

———. 2014. *San Francisco–Oakland Bay Bridge East Span Seismic Safety Project, Marine Mammal Incidental Harassment Authorization Annual Report, January 8, 2013–January 7, 2014*. Prepared by Garcia and Associates.

———. 2015a. *San Francisco–Oakland Bay Bridge East Span Seismic Safety Project, Pier E3 Demonstration Project, Preliminary Hydroacoustic Monitoring Results.* Prepared by Illingworth & Rodkin, Inc.

———. 2015b. *Marine Mammal Monitoring Annual Report Pier E3 Demolition: Test Blasts and Implosion September 9, 2015–December 30, 2015.* Prepared by BioMaAS and AECOM.

———. 2016. *San Francisco–Oakland Bay Bridge East Span Seismic Safety Project: Final SFOBB Pier E3 Implosion Demonstration Project Report.*

———. 2017. *San Francisco–Oakland Bay Bridge East Span Seismic Safety Project: Marine Foundation Removal Project Piers E4 and E5 Annual Environmental Post-Implosion Report.* Prepared by AECOM.

Carretta, J. V., K. A. Forney, and S. R. Benson. 2009. *Preliminary Estimates of Harbor Porpoise Abundance in California Waters from 2002 to 2007.* NOAA Technical Memorandum NOAA-TM-NMFSSWFSC-435.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell Jr., J. Robbins, D. K. Mattila, K. Ralls, and M. C. Hill. 2012. *U.S. Pacific Marine Mammal Stock Assessments: 2011.* U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-488.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, B. Hanson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, R. L. Brownell, D. K. Mattila, and M. C. Hill. 2013. *U.S. Pacific Marine Mammal Stock Assessments: 2012.* U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-504.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, B. Hanson, K. Martien, M. M. Muto, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, R. L. Brownell, and D. K. Mattila. 2014. *U.S. Pacific Marine Mammal Stock Assessments: 2013.* U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-532.

Carretta, J. V., E. M. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell. 2015. *U.S. Pacific Marine Mammal*

Stock Assessments: 2014. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TMNMFS-SWFSC-549.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell. 2017. *Draft U.S. Pacific Marine Mammal Stock Assessments: 2016*. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TMNMFS-SWFSC-XX.

Cole, R. H. 1948. *Underwater Explosions.* Princeton, NJ: Princeton University Press.

Conservation of Migratory Species of Wild Animals (CMS). 2015. *Marine Mammal Species Reports*. Available: http://www.cms.int/.

Craig, J. C., and C. W. Hearn. 1998. Appendix D, Physical Impacts of Explosions on Marine Mammals and Turtles. In *Final Environmental Impact Statement on Shock Testing of the Seawolf Submarine*, D1–D41. North Charleston, SC: Department of the Navy.

Crane, N. L., and K. Lashkari. 1996. Sound Production of Gray Whales, *Eschrichtius robustus*, along Their Migration Route: A New Approach to Signal Analysis. *Journal of the Acoustical Society of America* 100:1878–1886.

Cummings, W. C., and P. O. Thompson. 1971. Gray Whales, *Eschrichtius robustus*, Avoid the Underwater Sounds of Killer Whales, *Orcinus orca*. *Fishery Bulletin* 69:525–530.

Dahlheim, M. E., H. D. Fisher, and J. D. Schempp. 1984. Sound Production by the Gray Whale and Ambient Noise Levels in Laguna San Ignacio, Baja California Sur, Mexico. In: *The Gray Whale,* M. L. Jones, S. Swartz, and S. Leatherwood (editors), 511–541. Orlando, FL: Academic Press.

Dahlheim, M. E., and D. K. Ljungblad. 1990. Preliminary Hearing Study on Gray Whales (*Eschrichtius robustus*) in the Field. In *Sensory Abilities of Cetaceans: Laboratory and Field Evidence*, J. Thomas and R. Kastelein (editors), 335–346. New York: Plenum Press.

Danil, K., and J. A. St. Leger. 2011. Seabird and Dolphin Mortality Associated with Underwater Detonation Exercises. *Marine Technology Society Journal* 45(6):89–95.

Darling, J. D. 1984. Gray Whales off Vancouver Island, British Columbia. In *The Gray Whale*, Eschrichtius robustus, M. L. Jones, S. L. Swartz, and S. Leatherwood (editors), 267–287. Orlando, FL: Academic Press, Inc.

De Rango, G. Stranding Coordinator, The Marine Mammal Center, Sausalito, CA. December 2, 2013—e-mail to Phil Thorson at GANDA regarding stranded marine mammals in San Francisco Bay.

Dudzik, K. J., K. M. Baker, and D. W. Weller. 2006. *Mark-Recapture Abundance Estimate of California Coastal Stock Bottlenose Dolphins: February 2004 to April 2005.* SWFSC Administrative Report LJ-06-02C, available from Southwest Fisheries Science Center, La Jolla, CA.

Durban, J., D. Weller, A. Lang, and W. Perryman. 2013. *Estimating Gray Whale Abundance from Shore-Based Counts Using a Multilevel Bayesian Model.* Paper SC/65a/BRG02 presented to the International Whaling Commission.

Eguchi, T., and J. T. Harvey. 2005. Diving Behavior of the Pacific Harbor Seal (*Phoca vitulina richardii*) in Monterey Bay, California. *Marine Mammal Science* 21:283–295.

ESRI. 2015. DigitalGlobal, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo and the GIS User Community.

Fahy, C. 2015. *Guadalupe Fur Seal: Status Review*. 21st Biennial Conference on the Biology of Marine Mammals, December 13–18, 2015, San Francisco, CA.

Feldkamp, S. D., R. L. DeLong, and G. A. Antonelis. 1989. Diving Patterns of California Sea Lions, *Zalophus californianus*. *Canadian Journal of Zoology* 67:872–883.

Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder, and S. H. Ridgway. 2002. Temporary Shift in Masked Hearing Thresholds in *Odontocetes* after Exposure to

Single Underwater Impulses from a Seismic Watergun. *Journal of the Acoustical Society of America* 111:2929–2940.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway. 2003. Auditory and Behavioral Responses of California Sea Lions (*Zalophus californianus*) to Single Underwater Impulses from an Arc-Gap Transducer. *Journal of the Acoustical Society of America* 114:1667–1677.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary Threshold Shift in Bottlenose Dolphins (*Tursiops truncatus*) Exposed to Mid-frequency Tones. *Journal of the Acoustical Society of America* 118:2696–2705.

Finneran, J. J., and D. S. Houser. 2006. Comparison of In-Air Evoked Potential and Underwater Behavioral Hearing Thresholds in Four Bottlenose Dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 119:3181–3192.

Finneran, J. J. and A. K. Jenkins. 2012 (April). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy Technical Report. Space and Naval Warfare Systems Center Pacific, San Diego, CA.

Forney, K. A., J. V. Carretta, and S. R. Benson. 2013. *Preliminary Estimates of Harbor Porpoise Abundance in Pacific Coast Waters of California, Oregon, and Washington, 2007–2012.* Document PSRG-2013-10 submitted to the Pacific Scientific Review Group, 2–4 April 2013, San Diego, CA.

Gentry, R. L. 1998. *Behavior and Ecology of the Northern Fur Seal*. Princeton, NJ: Princeton University Press.

Gentry, R. L., D. P. Costa, J. P. Croxall, J. H. M. David, R. W. Davis, G. L. Kooyman, P. MajLuf, T. S. Mccann, and F. Trillmich. 1986. Synthesis and Conclusions. In *Fur Seals: Maternal Strategies on Land and at Sea*, R. L. Gentry and G. L. Kooyman (editors), 209–219. Princeton, NJ: Princeton University Press.

Gjertz, I., C. Lydersen, and Ø. Wiig. 1991. Distribution and Diving of Harbour Seals (*Phoca vitulina*) in Svalbard. *Polar Biology* 24:209–214.

Guan, S. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. December 30, 2015—e-mail to Courtney Cacace at AECOM regarding not needing IHA coverage for in-water mechanical dismantling activities.

Goertner, J. F. 1982. *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*. NSWC TR 82-188. Silver Springs, MD: Naval Surface Weapons Center, Dahlgren Division, White Oak Detachment.

Green, D. E., E. Grigg, S. Allen, and H. Markowitz. 2002. *Monitoring the Potential Impact of the Seismic Retrofit Construction Activities at the Richmond San Rafael Bridge on Harbor Seals* (Phoca vitulina)*: May 1998–February 2002*.

Grigg, E. K., D. E. Green, S. G. Allen, and H. Markowitz. 2002. Nocturnal and Diurnal Haul-Out Patterns of Harbor Seals (*Phoca vitulina richardsi*) at Castro Rocks, San Francisco Bay, California. *California Fish and Game* 88:15–27.

Gulland, F. M. D., F. B. Nutter, K. Dixon, J. Calambokidis, G. Schorr, J. Barlow, T. Rowles, S. Wilkin, T. Spradlin, L. Gage, J. Mulsow, C. Reichmuth, M. Moore, J. Smith, P. Folkens, S. F. Hanser, S. Jang, and C. S. Baker. 2008. Health Assessment, Antibiotic Treatment, and Behavioral Responses to Herding Efforts of a Cow-Calf Pair of Humpback Whales (*Megaptera novaeangliae*) in the Sacramento River Delta, California. *Aquatic Mammals* 34:182–192.

Hanggi, E. B., and R. J. Schusterman. 1994. Underwater Acoustic Displays and Individual Variation in Male Harbour Seals, *Phoca vitulina*. *Animal Behaviour* 48:1275–1283.

Harvey, J. T. and B. R. Mate. 1984. Dive Characteristics and Movements of Radio-tagged Gray Whales in San Ignacio Lagoon, Baja California Sur, Mexico. In *The Gray Whale*, M. L. Jones, S. Swartz and S. Leatherwood (editors), 561–575. Orlando, FL: Academic Press.

Harvey, J. T., and D. Goley. 2011. Determining a Correction Factor for Aerial Surveys of Harbor Seals in California. *Marine Mammal Science* 27:719–735.

Hastie, G. D., R. J. Swift, G. Slesser, P. M. Thompson, and W. R. Turrell. 2005. Environmental Models for Predicting Oceanic Dolphin Habitat in the Northeast Atlantic. *ICES Journal of Marine Science* 62:60e770.

Heath, C. B., and W. F. Perrin. 2008. California, Galapagos and Japanese Sea Lions *Zalophus californianus, Z. wollebaeki* and *Z. japonicus*. In *Encyclopedia of Marine Mammals* (second edition), W. F. Perrin, B. Würsig, and J. G. M. Thewissen (editors), 170–75.

Houser, D. S., and J. J. Finneran. 2007. A Comparison of Underwater Hearing Sensitivity in Bottlenose Dolphins (*Tursiops truncatus*) Determined by Electrophysiological and Behavioral Methods. *Journal of the Acoustical Society of America* 120:1713–1722.

Huber, H. R., S. J. Jeffries, R. F. Brown, R. L. DeLong, and G. VanBlaricom. 2001. Correcting Aerial Survey Counts of Harbor Seals (*Phoca vitulina richardsi*) in Washington and Oregon. *Marine Mammal Science* 17:276–293.

Jefferson, T. A., S. Leatherwood, and M. A. Webber. 1993. *FAO Species Identification Guide: Marine Mammals of the World.* Rome: Food and Agriculture Organization of the United Nations.

Jones, M. L., and S. L. Swartz. 2002. The Gray Whale (*Eschrichtius robustus*). In *Encyclopedia of Marine Mammals*, W. F. Perrin, B. Würsig, and J. G. M. Thewissen (editors), 524–536. San Diego, CA: Academic Press.

Kastak, D., and R. J. Schusterman. 1998. Low-Frequency Amphibious Hearing in Pinnipeds: Methods, Measurements, Noise, and Ecology. *Journal of the Acoustical Society of America* 103:2216–2228.

———. 2002. Changes in Auditory Sensitivity with Depth in a Freediving California Sea Lion (*Zalophus californianus*). *Journal of the Acoustical Society of America* 112:329–333.

Kastak, D., R. J. Schusterman, B. L. Southall, and C. J. Reichmuth. 1999. Underwater Temporary Threshold Shift Induced by Octave-Band Noise in Three Species of Pinniped. *Journal of Acoustical Society of America* 106:1142–1148.

Kastelein, R., P. Bunskoek, M. Hagedoorn, W. W. L. Au, and D. de Haan. 2002. Audiogram of a Harbor Porpoise (*Phocoena phocoena*) Measured with Narrow-Band Frequency-Modulated Signals. *Journal of the Acoustical Society of America* 112:334–344.

Kastelein, R., D. van Heerden, R. Gransier, and L. Hoek. 2013. Behavioral Responses of a Harbor Porpoise (*Phocoena phocoena*) to Playbacks of Broadband Pile Driving Sounds. *Marine Environmental Research* 92:206–214.

Keener, B., I. Sczepaniack, J. Stern, and M. Webber. 2012. *Harbor Porpoises of the San Francisco Bay*. Report of Golden Gate Cetacean Research.

Keener, B. 2017. *Ask the Naturalist: Why Are There Humpback Whales in the San Francisco Bay Right Now?* Golden Gate Cetacean Research, featured on Bay Nature. Available: https://baynature.org/article/ask-naturalist-humpback-whales-san-francisco-bay-right-now/. Accessed November 13, 2017.

Ketten, D. R. 1992. The Marine Mammal Ear: Specializations for Aquatic Audition and Echolocation. In *The Evolutionary Biology of Hearing*, D. Webster, R. R. Fay, and A. N. Popper (editors), 717–754. New York: Springer-Verlag.

———. 1998 (September). *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Its Implications for Underwater Acoustic Impacts*. NOAA Technical Memorandum. La Jolla, CA.

Kiewit. 2015. *Construction Plans for the Removal of Pier E3 of the East Span of the San Francisco-Oakland Bay Bridge*.

Klima, E. F., G. R. Gitschlag, and M. L. Renaud. 1988. Impacts of Explosive Removal of Offshore Petroleum Platforms on Sea Turtles and Dolphins. *Marine Fisheries Review* 50:33–42.

Knudsen, S. K., and E. O. Øen. 2003. Blast-Induced Neurotrauma in Whales. *Neuroscience Research* 46:377–386.

Kooyman, G. L., D. D. Hammond, and J. P. Schroeder. 1970. Bronchograms and Tracheograms of Seals under Pressure. *Science* 169:82–84.

Kooyman, G. L., R. L. Gentry, and D. L. Urquhart. 1976. Northern Fur Seal Diving Behavior–New Approach to Its Study. *Science* 193:411–412.

Lander, M. Research Assistant, Moss Landing Marine Laboratory. 1999—e-mail with Phil Thorson at ManTech SRS Technologies, Inc. regarding fur seal movements.

Le Boeuf, B. J., P. A. Morris, S. D. Blackwell, D. E. Crocker, and D. P. Costa. 1996. Diving Behavior of Juvenile Northern Elephant Seals. *Canadian Journal of Zoology* 74:1632–1644.

London, J. M., J. M. Ver Hoef, S. J. Jeffries, M. M. Lance, and P. L. Boveng. 2012. Haul-Out Behavior of Harbor Seals (*Phoca vitulina*) in Hood Canal, Washington. *PLoS ONE* 7(6):e38180.

Lowry, M. S., P. Boveng, R. J. DeLong, C. W. Oliver, B. S. Stewart, H. DeAnda, and J. Barlow. 1992. *Status of the California Sea Lion (*Zalophus californianus californianus*) Population in 1992*. Administrative Report LJ-92-32. La Jolla, CA: Southwest Fisheries Science Center, National Marine Fisheries Service.

Lowry, M. S., R. Condit, B. Hatfield, S. G. Allen, R. Berger, P. A. Morris, B. J. Le Boeuf, and J. Reiter. 2010. Abundance, Distribution, and Population Growth of the Northern Elephant Seal (*Mirounga angustirostris*) in the United States from 1991 to 2010. *Aquatic Mammals* 40:20–31.

Lowry, M. S., R. Condit, B. Hatfield, S. G. Allen, R. Berger, P. A. Morris, B. J. Le Boeuf, and J. Reiter. 2014. Abundance, Distribution, and Population Growth of the Northern Elephant Seal (*Mirounga angustirostris*) in the United States from 1991 to 2010. *Aquatic Mammals* 40:20–31.

Lowry, M. S., and K. A. Forney. 2005. Abundance and Distribution of California Sea Lions (*Zalophus californianus*) in Central and Northern California during 1998 and Summer 1999. *Fisheries Bulletin* 103:331–343.

Lowther-Thieleking, J., F. Archer, A. Lang, and D. Weller. 2015. Genetic Differentiation among Coastal and Offshore Bottlenose Dolphins, *Tursiops truncatus*, in the Eastern North Pacific Ocean. *Marine Mammal Science* 31:1–20.

Lucke, K., U. Siebert, P. A. Lepper, and M.-A. Blanchet. 2009. Temporary Shift in Masked Hearing Thresholds in a Harbor Porpoise (*Phocoena phocoena*) after Exposure to Seismic Airgun Stimuli. *Journal of the Acoustical Society of America* 125:4060–4070.

Madsen, P. T., M. Johnson, P. J. Miller, N. Aguilar Soto, J. Lynch, and P. Tyack. 2006. Quantitative Measures of Air-Gun Pulses Recorded on Sperm Whales (*Physeter*

macrocephalus) Using Acoustic Tags during Controlled Exposure Experiments. *Journal of the Acoustical Society of America* 120:2366–2379.

Malcolm, C. D., D. A. Duffus, and S. G. Wischniowski. 1995/1996. Small Scale Behaviour of Large Scale Subjects: Diving Behaviour of a Gray Whale (*Eschrichtius robustus*). *Western Geography* 5/6:35–44.

Malcolm, C. D., and D. A. Duffus. 2000. Comparison of Subjective and Statistical Methods of Dive Classification Using Data from a Time-Depth Recorder Attached to a Gray Whale (*Eschrichtius robustus*). *Journal of Cetacean Research and Management* 2:177–182.

Malme, C. I., B. Würsig, J. E. Bird, and P. L. Tyack. 1986. *Behavioral Responses of Gray Whales to Industrial Noise: Feeding Observations and Predictive Modeling*. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Final Report of the Principal Investigators. BBB Report No. 6265. OCS Study MMS 88-0048; NTIS PB88-249008. Anchorage, AK.

Manugian, S. 2013. *Survival and Movement of Female Harbor Seals (Phoca vitulina) in San Francisco and Tomales Bays, California*. Master's thesis, Moss Landing Marine Laboratory.

Manugian, S. C., D. J. Greig, D. Lee, B. H. Becker, S. Allen, M. S. Lowry, and J. T. Harvey. 2017. Survival Probabilities and Movements of Harbor Seals in Central California. *Marine Mammal Science* 33:154-171.

———. 2017. List of patients from 2014–2017. Available: http://www.marinemammalcenter.org/patients/current-patients-page/. Accessed March 8, 2017.

Melin, S. R., R. L. De Long, and D. B. Siniff. 2008. The Effects of El Niño on the Foraging Behavior of Lactating California Sea Lions (*Zalophus californianus californianus*) during the Nonbreeding Season. *Canadian Journal of Zoology* 86:192–206.

Miller, P. J. O., M. P. Johnson, P. T. Madsen, N. Biassoni, M. Quero, and P. L. Tyack. 2009. Using At-Sea Experiments to Study the Effects of Airguns on the Foraging

Behavior of Sperm Whales in the Gulf of Mexico. *Deep-Sea Research I* 56:1168–1181.

Møhl, B. 1968. Auditory Sensitivity of the Common Seal in Air and Water. *Journal of Auditory Research* 8:27–38.

Mooney, T. A., P. E. Nachtigall, M. Breese, S. Vlachos, and W. W. L. Au. 2009. Predicting Temporary Threshold Shifts in a Bottlenose Dolphin (*Tursiops truncatus*): The Effects of Noise Level and Duration. *Journal of the Acoustical Society of America* 125:1816–1826.

Moore, J.E., and J. Barlow. 2011. Bayesian State-Space Model of Fin Whale Abundance Trends from a 1991-2008 Time Series of Line-Transect Surveys in the California Current. *Journal of Applied Ecology* 48:1195–1205.

Moore, P. W., and R. J. Schusterman. 1987. Audiometric Assessment of Northern Fur Seals (*Callorhinus ursinus*). *Marine Mammal Science* 3:31–53.

Moore, S. E., and J. T. Clarke. 2002. Potential Impact of Offshore Human Activities on Gray Whales, *Eschrichtius robustus*. *Journal of Cetacean Research and Management* 4:19–25.

Muto, M. M., Helker, V.T., Angliss, B.A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. *Alaska Marine Mammal Stock Assessments, 2016.* U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-355.

Nachtigall, P. E., D. W. Lemonds, and H. L. Roitblat. 2000. Psychoacoustic Studies of Whale and Dolphin Hearing. In *Hearing By Whales*, W. W. L. Au, A. N. Popper, and R. J. Fay (editors), 330–364. New York: Springer–Verlag.

Nachtigall, P. E., A. Ya. Supin, J. L. Pawloski, and W. W. L. Au. 2004. Temporary Threshold Shifts after Noise Exposure in the Bottlenose Dolphin (*Tursiops truncatus*) Measured Using Auditory Evoked Potentials. *Marine Mammal Science* 20:673–687.

Nadeem, K., J. E. Moore, Y. Zhang, and H. Chipman. 2016. Integrating Population Dynamics Models and Distance Sampling Data: A Spatial Hierarchical State-Space Approach. *Ecology* 10.1890/15-1406.1

National Marine Fisheries Service (NMFS). 2016. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55.

National Oceanic and Atmospheric Administration (NOAA). 2013. Endangered and Threatened Species: Delisting of the Eastern Distinct Population Segment of Steller Sea Lion under the Endangered Species Act; Amendment to Special Protection Measures for Endangered Marine Mammals. *Federal Register* 78 (206).

———.2016. Taking of Marine Mammals Incidental to Specified Activities; Construction of the East Span of the San Francisco-Oakland Bay Bridge. *Federal Register* 81 (143).

Nerini, M. 1984. A Review of Gray Whale Feeding Ecology. In *The Gray Whale,* Eschrichtius robustus, M. L. Jones, S. L. Swartz, and S. Leatherwood (editors), 423–450. Orlando, FL: Academic Press, Inc.

Nowacek, D., L. H. Thorne, D. Johnston, and P. Tyack. 2007. Responses of Cetaceans to Anthropogenic Noise. *Mammal Review* 37:81–115.

Otani, S., Y. Naito, A. Kato, and A. Kawamura. 2000. Diving Behavior and Swimming Speed of a Free-Ranging Harbor Porpoise, *Phocoena Phocoena. Marine Mammal Science* 16(4):811–814.

Parvin, S. J., J. R. Nedwell, and E. Harland. 2007 (February). *Lethal and Physical Injury of Marine Mammals, and Requirements for Passive Acoustic Monitoring.* Subacoustech Report Reference: 565R0212. Submitted to the U.K. Government Department of Business, Enterprise and Regulatory Reform, London.

Patterson, J., and A. Acevedo-Gutiérrez. 2008. Tidal Influence on the Haul-Out Behavior of Harbor Seals (*Phoca vitulina*) at a Site Available at All Tide Levels. *Northwestern Naturalist* 89:17–23.

Perlman, D. 2017. *Warmer Waters Have More Bottlenose Dolphins Turning Up in San Francisco Bay*. SFGATE.

Phillips, Y. Y., and D. Richmond. 1990. Primary Blast Injury and Basic Research: A Brief History. In *Textbook of Military Medicine. Part I. Warfare, Weapons, and the Casualty, Volume 5, Conventional Warfare. Ballistic, Blast, and Burn Injuries*, R. Zatchuck, D. P. Jenkins, R. F. Bellamy, and C. M. Quick (editors), 221–240. Washington, DC: TMM Publications.

Read, A. J. 1990. Reproductive Seasonality in Harbor Porpoises, *Phocoena phocoena*, from the Bay of Fundy. *Canadian Journal of Zoology* 68:284–288.

Reeves, R. R. 2002. Conservation Efforts. In *Encyclopedia of Marine Mammals*, W. F. Perrin, B. Würsig, and J. G. M. Thewissen (editors), 276–297. San Diego, CA: Academic Press.

Reyff, J. 2015a. *San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Pier E3 Removal, Hoe Ram Demolition – Hydroacoustic Measurements for June 25 and 29, 2015*. Illingworth & Rodin, Inc. monitoring memorandum.

Reyff, J. 2015b. *San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Pier E3 Removal, Hoe Ram Demolition – Hydroacoustic Measurement for July 16, 2015.* Illingworth & Rodkin, Inc. monitoring memorandum.

Rice, D. W., and A. A. Wolman. 1971. *The Life History and Ecology of the Gray Whale* (Eschrichtius robustus). Stillwater, OK: American Society of Mammalogists.

Richardson, W. J., C. R. Greene, C. I. Malme, and D. H. Thomson. 1995. *Marine Mammals and Noise.* San Diego, CA: Academic Press.

Ridgway, S. H., B. L. Scronce, and J. Kanwisher. 1969. Respiration and Deep Diving in the Bottlenose Porpoise. *Science* 166 (3913):1651–1654.

Ridgway, S. H., and R. Howard. 1979. Dolphin Lung Collapse and Intramuscular Circulation during Free Diving: Evidence from Nitrogen Washout. *Science* 206:1182–1183.

Riedman, M. 1990. *The Pinnipeds: Seals, Sea Lions, and Walruses.* Berkeley: University of California Press.

Robinson, P. W., D. P. Costa, D. E. Crocker, J. P. Gallo-Reynoso, C. D. Champagne, M. A. Fowler, C. Goetsch, K. T. Goetz, J. L. Hassrick, L.A. Hückstädt, C. E. Kuhn, J. L. Maresh, S. M. Maxwell, B. I. McDonald, S. H. Peterson, S. E. Simmons, N. M. Teutschel, S. Villegas-Amtmann, and K. Yoda. 2012. Foraging Behavior and Success of a Mesopelagic Predator in the Northeast Pacific Ocean: Insights from a Data-Rich Species, the Northern Elephant Seal. *PLoS ONE* 7(5):e36728.

Rodkin, 2009. *SFOBB – Results of Hydroacoustic Measurements at Temporary Tower F North for three 48-inch Steel Pipe Piles (Battered) Driven January 15, 2009.* Illingworth & Rodkin, Inc. monitoring memorandum.

Schusterman, R. J. 1969. Underwater Barking by Male Sea Lions (*Zalophus californianus*). *Nature* 1179–1180.

———. 1974. Auditory Sensitivity of a California Sea Lion to Airborne Sound. *Journal of the Acoustical Society of America* 56:1248–1251.

Schusterman, R. J., R. Gentry, and J. Schmook. 1966. Underwater Vocalization by Sea Lions: Social and Mirror Stimuli. *Science* 154:540–542.

———. 1967. Underwater Sound Production by Captive California Sea Lions. *Zoologica* 52:21–24.

Schusterman, R. J., R. F. Balliet, and J. Nixon. 1972. Underwater Audiogram of the California Sea Lion by the Conditioned Vocalization Technique. *Journal of the Experimental Analysis of Behavior* 17:339–350.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. Finneran, R. Gentry, C. R. Green, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A.

Thomas, and P. L. Tyack. 2007. Marine Mammal Noise Exposure Criteria. *Aquatic Mammals* 33:411–521.

Stewart, B. S. 1989. *The Ecology and Population Biology of the Northern Elephant Seal,* Mirounga angustirostris (*Gill*) *1866, on the Southern California Channel Islands*. Ph.D. dissertation, University of California, Los Angeles.

Stewart, B. S., and P. K. Yochem. 1994. Ecology of Harbor Seals in the Southern California Bight. In *The Fourth California Islands Symposium: Update on the Status of Resources,* W. L. Halverson and G. J. Maender (editors), 123–134. Santa Barbara, CA: Santa Barbara Museum of Natural History.

Stewart, B. S., and R. L. DeLong. 1995. Double Migrations of the Northern Elephant Seal, *Mirounga angustirostris*. *Journal of Mammalogy* 76:196–205.

Szczepaniak, I., W. Keener, M. Webber, J. Stern, D. Maldini, M. Cotter, R.H. Defran, M. Rice, G. Campbell, A. Debich, A.R. Lang, D.L. Kelly, A. Kesaris, M. Bearzi, K. Causey, and D.W. Weller. 2013. *Bottlenose Dolphins Return to San Francisco Bay*. Poster presented at 20th Biennial Conference of Marine Mammalogy, New Zealand.

Terhune, J. M. 1968. Detection Thresholds of a Harbour Seal to Repeated Underwater High-Frequency, Short-Duration Sinusoidal Pulses. *Canadian Journal of Zoology* 66:1578–1582.

Terhune, J., and S. Turnbull. 1995. Variation in the Psychometric Functions and Hearing Thresholds of a Harbour Seal. In *Sensory Systems of Aquatic Mammals*, R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall (editors), 81–93. Woerden, The Netherlands: De Spil Publishers.

Thorson, P. H., and B. J. Le Boeuf. 1994. Developmental Aspects of Diving in Northern Elephant Seal Pups. In *Elephant Seals: Population Ecology, Behavior, and Physiology*, B. J. Le Boeuf and R. M. Laws (editors), 271–289. Berkeley: University of California Press.

Thorson, P. H., and K. Wagner. 2001. *Marine Mammal Monitoring of the San Francisco–Oakland Bay Bridge Pile Installation Demonstration Project:*

September–December 2000. Prepared for the California Department of Transportation, Contract No. 04-12084.

Tinker, M. T., and B. B. Hatfield. 2015. *Southwest U.S. Southern Sea Otter Annual Range-wide Census Results*. U.S. Geological Survey data release. Available: http://dx.doi.org/10.5066/F7F47M5C. Accessed January 12, 2016.

Tinker, M.T., and B.B. Hatfield. 2016. *California Sea Otter (Enhydra lutris nereis) Census Results, Spring 2016*. U.S. Geological Survey Data Series 1018.

Turl, C. W. 1993. Low-Frequency Sound Detection by a Bottlenose Dolphin. *Journal of the Acoustical Society of America* 94(5):3006–3008.

U.S. Fish and Wildlife Service (USFWS). 2017. *Southern Sea Otter (Enhydra lutris nereis).* Final Southern Sea Otter Stock Assessment Report 2017. U.S. Fish and Wildlife Service, Ventura, California.

Van Parijs, S. M., P. J. Corkeron, J. Harvey, S. A. Hayes, D. K. Mellinger, P. A. Rouget, P. M. Thompson, M. Wahlberg, and K. M. Kovacs. 2003. Patterns in the Vocalizations of Male Harbor Seals. *Journal of the Acoustical Society of America* 113:3403–3410.

Verboom, W. C., and R. A. Kastelein. 1995. Acoustic Signals by Harbour Porpoises (*Phocoena phocoena*). In *Harbour Porpoises—Laboratory Studies to Reduce Bycatch*, P. E. Nachtigall, J. Lien, W. W. L. Au, and A. J. Read (editors), 1–39. Woerden, The Netherlands: De Spil Publishers.

Wartzok, D., A. N. Popper, J. Gordon, and J. Merrill. 2003. Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. *Marine Technology Society Journal* 37:6–15.

Weller, D. W., G. S. Campbell, A. Debich, A. G. Kesaris, and R. H. Defran. 2016. *Mark-recapture Abundance Estimate of California Coastal Stock Bottlenose Dolphins: November 2009 to April 2011*. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-563.

Westgate, A. J., A. J. Read, P. Berggren, H. N. Koopman, and D. E. Gaskin. 1995. Diving Behaviour of Harbour Porpoises, *Phocoena phocoena*. *Canadian Journal of Fisheries and Aquatic Science* 52:1064–1073.

Wolski, L. F., R. C. Anderson, A. E. Bowles, and P. K. Yochem. 2003. Measuring Hearing in the Harbor Seal (*Phoca vitulina*): Comparison of Behavioral and Auditory Brainstem Response Techniques. *Journal of the Acoustical Society of America* 113:629–637.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones. 1973. *Safe Distances from Underwater Explosions for Mammals and Birds*. Report by Lovelace Foundation for Medical Education and Research, Albuquerque, NM, for Defense Nuclear Agency, Washington, DC. DNA 3114T.

Yochem, P. K., B. S. Stewart, R. L. DeLong, and D. P. DeMaster. 1987. Diel Haul-Out Patterns and Site Fidelity of Harbor Seals (*Phoca vitulina richardsi*) on San Miguel Island, California, in Autumn. *Marine Mammal Science* 3:323–332.

Appendix A. Piers E3 and E5 Test Blast Hydroacoustic Monitoring Results

Appendix B. Alternatives Analysis