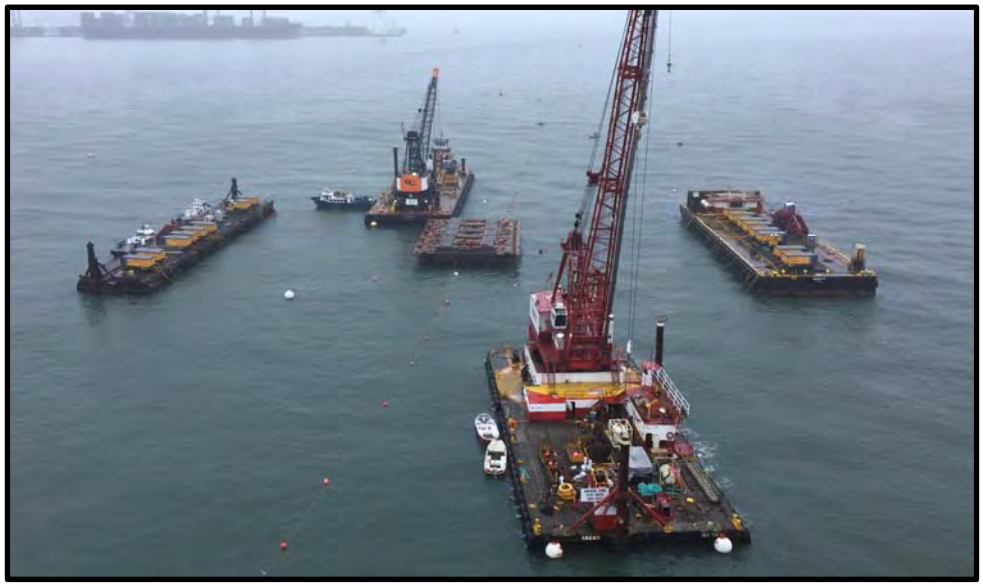
SAN FRANCISCO–OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT



INCIDENTAL HARASSMENT AUTHORIZATION APPLICATION

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

EA 04-013574
EFIS#: 0412000287
04-SF-80 KP 12.2/KP 14.3

04-ALA-80 KP 0.0/KP 2.1

April 2017

California Department of Transportation

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California Department of Transportation

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The environmental review, consultation, and any other action required in accordance with applicable Federal laws for this project is being, or has been, carried-out by the Department under its assumption of responsibility pursuant to 23 USC 327.

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List of Abbreviated Terms

µPa	micropascal(s)
BART	Bay Area Rapid Transit
BAS	Blast Attenuation System
Bay	San Francisco Bay
Department	California Department of Transportation
dB	decibel(s)
FESA	Federal Endangered Species Act
GI	gastro-intestinal
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
MMC	Marine Mammal Center
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
SFOBB	San Francisco–Oakland Bay Bridge
SFOBB Project	San Francisco–Oakland Bay Bridge East Span Seismic Safety Project
SPL	sound pressure level
TTS	Temporary Threshold Shift
YBI	Yerba Buena Island
ZOI	zone of influence

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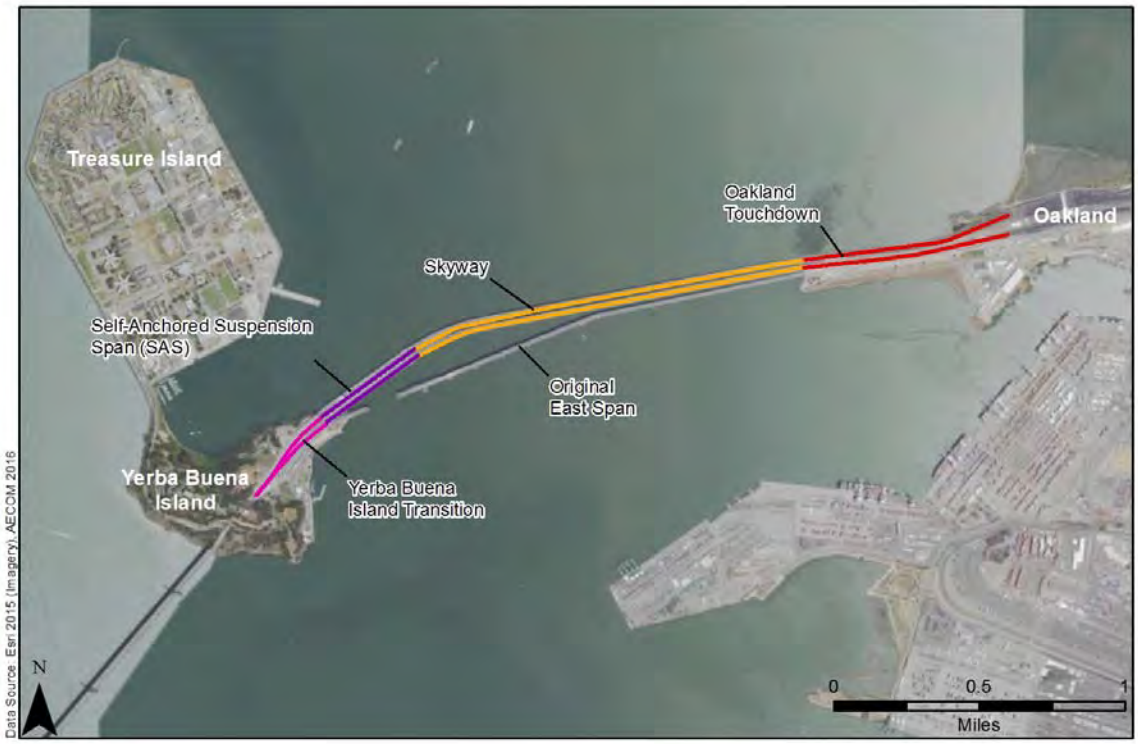
Chapter 1. Description of Specified Activity

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 and dismantling the original east span. The Department currently is in the dismantling phase of the original east span. The Department is requesting regulatory authorization for the incidental harassment of marine mammals resulting from activities associated with demolition of marine foundations of the existing east span. These activities include the use of highly controlled charges to dismantle 13 marine foundations, Piers E6 to E18 (Figure 2).

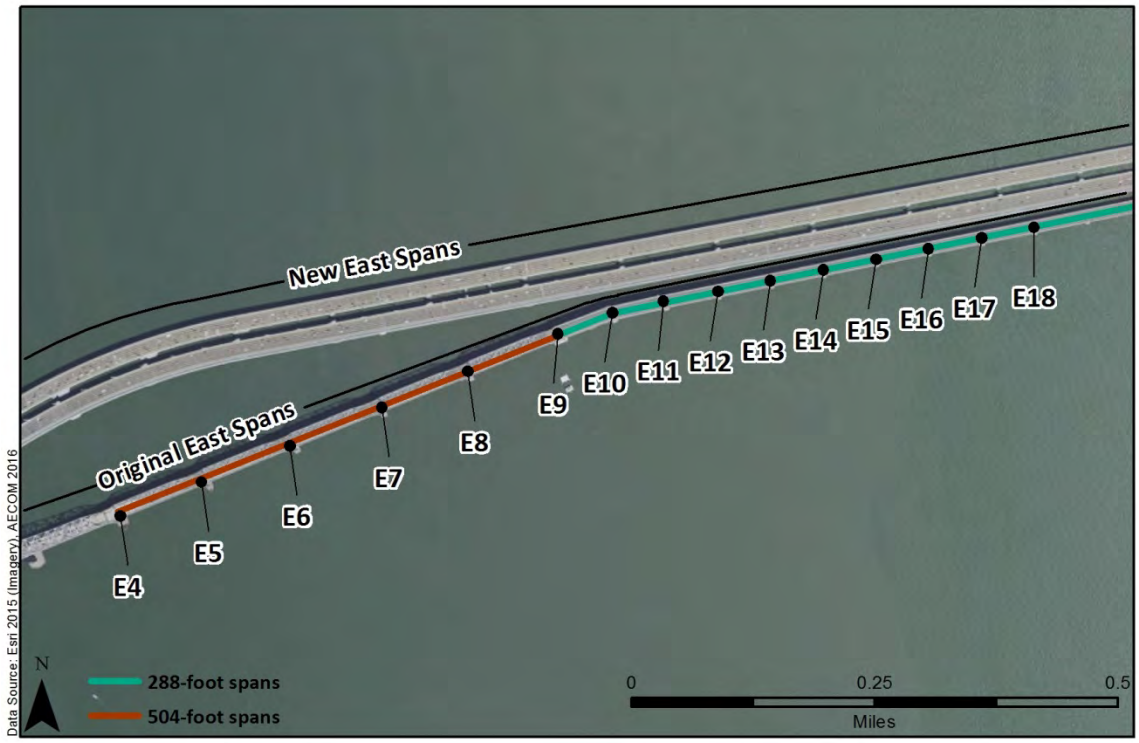


Source: ESRI 2015 (imagery); compiled by AECOM in 2016

Figure 1. Sections of the SFOBB New 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



Source: ESRI 2015 (imagery); compiled by AECOM in 2016

Figure 2. SFOBB East Span, Locations of Original East Span Marine Foundations, Piers E4 to E18

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 10 subsequent IHAs for the SFOBB Project, in 2005, 2007, 2009, 2011, January and December 2013, 2014, July and September 2015, and 2016. 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 the 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.

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 would not result in the incidental take of marine mammals as defined under the MMPA. Therefore, the 2016 IHA did not include mechanical dismantling, and the Department is not requesting coverage under this IHA application to conduct these in-water mechanical dismantling activities.

The Department does not anticipate any further in-water pile installation or pile removal for the SFOBB Project. Therefore, the Department is not requesting coverage under this IHA application to conduct pile driving activities.

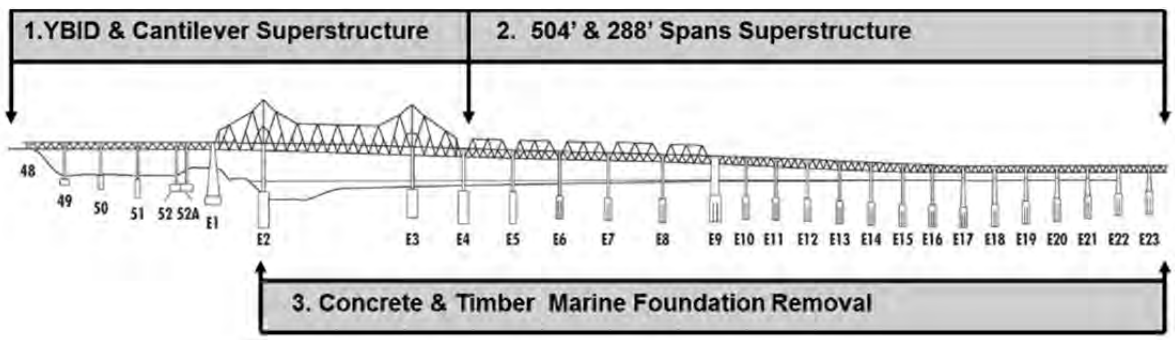
In accordance with the conditions of the September 2015 and 2016 IHAs, the Department successfully imploded Piers E3, E4, and E5 with highly controlled charges. The successful implosion of the piers, as well as the results from hydroacoustic, biological, and water quality monitoring that were conducted 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, E4, and E5 will be used to inform anticipated sound pressure levels (SPLs) and distances to marine mammal threshold criteria for the implosions of Piers E6 through E18.

1.1.1. Project Area

The SFOBB project area is located in the central part of the San Francisco Bay (the Bay) between Yerba Buena Island (YBI) and the city of Oakland. The western limit of the project area is the east portal of the YBI tunnel, located in the city of San Francisco. The eastern limit of the project area is located approximately 1,312 feet (400 meters) west of the Bay Bridge toll plaza, where the new and former spans connect with land at the Oakland Touchdown (OTD) in the city of Oakland.

1.1.2. History of the Original East Span

Construction of the original east span connecting YBI and the Oakland shoreline was completed in 1936. The original east span was a double-deck structure, 12,127 feet (3,696 meters) in length and approximately 58 feet (18 meters) wide. It was constructed and opened with six traffic lanes on the upper deck; the lower deck had two rail lines, one lane for large trucks, and two lanes for traffic. From 1963 to the time of decommission, the original east span carried five traffic lanes on each of the upper and lower decks. The original east span was supported by 21 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 shows the breakdown of the original east span, divided into three major sections.



Source: Department 2016

Figure 3. Elevation View of the SFOBB Original East Span

The three major sections of the original east span can be described as follows.

CANTILEVER SUPERSTRUCTURE AND YBI DETOUR

Cantilever Superstructure: A cantilever bridge consisting of two 511-foot side spans and a 1,400-foot main span over the navigation channel immediately east of YBI. Removal of this structure was completed in 2015.

YBI Detour: To complete construction of the new SFOBB east span and tie into the YBI tunnel, a portion of the original east span between Pier E1 and the YBI tunnel was dismantled in 2009, and was replaced with the YBI Detour. The YBI Detour consisted of a double-decked bypass structure that connected to the original east span at Pier E1 on the east side of YBI.

504-FOOT AND 288-FOOT SPANS SUPERSTRUCTURE

The 504-foot and 288-foot spans superstructure (504/288) segment of the bridge is made up of five 504-foot-long (153.6 meters) steel truss spans and fourteen 288-foot-long (87.8 meters) steel truss spans. The vertical clearance beneath the spans gradually

decreases as the structure descends to the OTD. The superstructure includes trusses, road deck, and steel support towers.

CONCRETE AND TIMBER MARINE FOUNDATIONS

The marine foundations vary in structural type. 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 35 feet (11 meters) that bears on rock.
Piers E3, E4, and E5 are founded on concrete caissons that were advanced over 130 feet (40 meters) into the soil beneath the waters of the Bay. The in-water portion of Pier E3 was removed in 2015, to demonstrate the efficacy of controlled, engineered blasting for demolition of marine piers. The in-water portions of Piers E4 and E5 were removed in 2016, using controlled, engineered blasting. Piers E6 to E22 consist of lightly reinforced concrete foundations that are supported by timber piles driven into the Bay mud. The Department is proposing removal of Piers E6 through E18 in 2017, using controlled, engineered blasting.

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. The dismantling work was divided into multiple components, corresponding to the different sections of the original east span (Figures 2 and 3).

These components include the following:

- Dismantling the cantilever superstructure and YBI Detour span, and the supporting steel tower legs;
- Dismantling the 504/288 segment's steel trusses and the supporting steel tower legs; and
- Removing the Marine Foundations.

Dismantling the cantilever superstructure and YBI Detour span was completed in June 2015. Removing the 504-foot and 288-foot spans began in mid-2015 and is ongoing (Figure 4). Marine foundation removal began with the dismantling of Pier E3, initiated in April 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 foundations.

Source: ESRI 2015 (imagery); compiled by AECOM in 2016

Figure 4. Sections of the SFOBB Original East Span

On November 14, 2015, as part of the Demonstration Project, Pier E3 of the original east span was successfully imploded with highly controlled charges. The pier was imploded into its open hollow cellular chambers below the mudline (i.e., the Bay floor). A Blast Attenuation System (BAS) and other avoidance and minimization measures were effective in minimizing potential impacts on biological resources in the Bay. The data that was collected for the Demonstration Project indicated greater reduction and minimization of environmental impacts than originally modeled and proposed by the Department. Controlled blasting removal greatly reduced in-water work periods for Pier E3, from approximately 3 to 4 years to a few weeks.

On October 15, 2016, Pier E5, and on October 29, 2016, Pier E4 of the original east span were successfully imploded with highly controlled charges. As during the implosion of Pier E3, these piers also were imploded into their open hollow cellular chambers below the mudline (i.e., the Bay floor). BASs and other avoidance and minimization measures again were effective in minimizing potential impacts on the environment and biological resources in the Bay. The data that was collected for these implosions indicated greater reduction and minimization of environmental impacts than where realized during the implosion of Pier E3. The results from the implosions of Piers E3, E4, and E5 support the

finding that use of controlled blasting reduces adverse effects on the environment and biological resources compared to conventional dismantling methods (i.e., cofferdams, pile driving, and mechanical dismantling).

Based on the results of previous pier implosions, the Department believes that using controlled charges to remove the remaining marine foundations will be the least environmentally damaging practicable alternative. The next phase of marine foundation removal will incorporate the experience from previous marine foundation removal to remove Piers E6 through E18, using both mechanical and controlled blasting methods (Figures 2 and 4).

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

Construction activities associated with dismantling marine foundations of the original east span potentially may result in incidental take of marine mammals. These activities include the use of highly controlled charges to dismantle the Pier E6 through Pier E18 marine foundations.

The Department proposes the removal of the concrete marine foundations of Piers E6 to E18 of the original east span, using controlled charges. The limits of removal have been determined at each location, to 3 feet below the mudline.

Piers E6 to E18 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. Unlike Piers E3 to E5, the cellular structures of Piers E6 to E18 do not extend deep below the mudline. The timber piles and concrete slabs that are below approved removal limits will remain in place. Rubble that mounds above the determined debris removal elevation limits from the dismantling of Piers E6 to E18 will be removed off-site for disposal. A BAS similar to that used for the Pier E3, E4, and E5 implosions will be used during all future controlled blasting events, to minimize potential impacts on biological resources in the Bay.

1.2.1. Piers E6 to E18 Site Locations

Piers E6 to E18 of the original east span are located in the Bay. Pier E6 straddles the border that delineates the City and County of San Francisco from the City of Oakland in Alameda County. Piers E7 to E18 are located in the City of Oakland. All the piers are located between the OTD and YBI, and are situated south of the SFOBB new east span

(Figure 2). Piers E6 to E8 formerly supported the 504-foot bridge spans. Pier E9 is located at the connection point between the 288-foot bridge spans and 504-foot bridge spans. Piers E10 to E18 formerly supported the 288-foot bridge spans. The approximate water depth varies by pier location. Approximate location information for each pier is shown in Table 1.

Table 1. Location Details for Marine Foundations of the SFOBB Original East Span

Pier Number	Approximate Distance to YBI		Approximate Distance to OTD		Approximate Coordinates
	Feet	Meters	Feet	Meters	
E6	3,058	932	5,511	1,680	37º 49' 02.38"N, 122º 20' 56.93"W
E7	3,580	1,091	5,008	1,526	37º 49' 04.23"N, 122º 20' 50.90"W
E8	4,070	1,241	4,504	1,373	37º 49' 06.18"N, 122º 20' 45.14"W
E9	4,590	1,399	4,001	1,220	37º 49' 08.13"N, 122º 20' 39.17"W
E10	4,897	1,493	3,688	1,124	37º 49' 09.24"N, 122º 20' 35.57"W
E11	5,185	1,580	3,404	1,038	37º 49' 09.83"N, 122º 20' 31.97"W
E12	5,478	1,670	3,110	948	37º 49' 10.43"N, 122º 20' 28.43"W
E13	5,765	1,757	2,818	859	37º 49' 11.00"N, 122º 20' 24.90"W
E14	6,053	1,845	2,526	770	37º 49' 11.56"N, 122º 20' 21.25"W
E15	6,343	1,933	2,232	680	37º 49' 12.06"N, 122º 20' 17.69"W
E16	6,628	2,020	1,951	595	37º 49' 12.64"N, 122º 20' 14.19"W
E17	6,923	2,110	1,666	508	37º 49' 13.24"N, 122º 20' 10.68"W
E18	7,216	2,199	1,376	419	37º 49' 13.75"N, 122º 20' 06.97"W

Source: Compiled by AECOM in 2016

1.2.2. Pier E6 to E18 Descriptions

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

Since their original construction, a local scour has developed around each pier. As currents in the Bay flow past each pier, the water is forced to speed up as it is pushed into the pier. This localized increase in current speed around each pier allows the water to pick up the sediment around the pier and effectively digs a hole around the solid structure. After pier removal, sediment will redeposit at all former pier locations and the scoured areas will return naturally to the surrounding mudline elevation. Removal limits for each pier are 3 feet below the average mudline in the areas outside the scour of each pier.

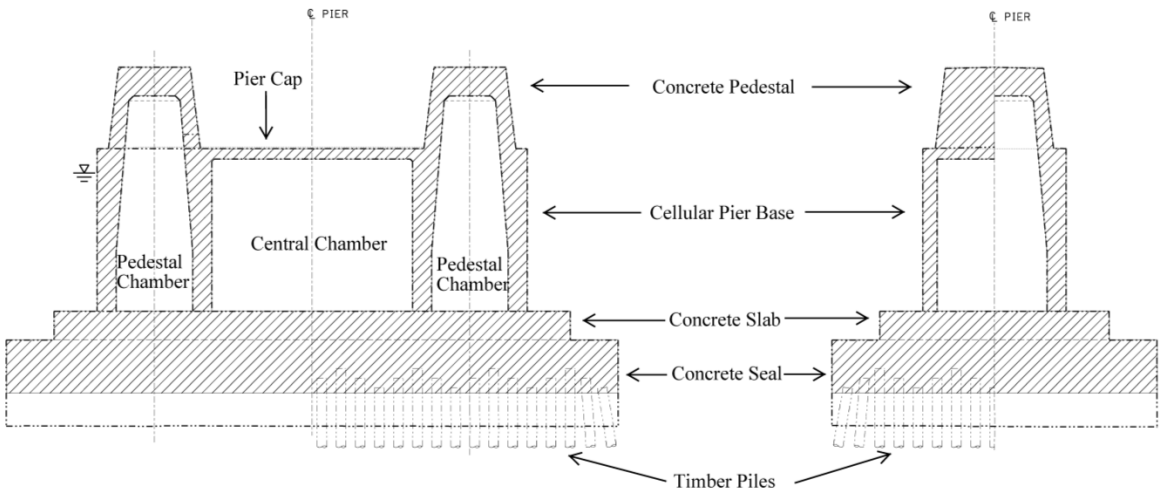
The mudline rises as it approaches the Oakland shoreline. Therefore, the water depth becomes shallower progressing from Pier E6 to E18. The scour depth around each pier differs by location as well. The approximate undisturbed mudline elevations around Piers E6 to E18, based on the most recent surveys taken in 2016, are shown in Table 2. On February 29, 2016, the Department received concurrence from the United States Coast Guard for the proposed limits of removal that are shown in Table 2.

Table 2. Approximate Mudline and Removal Elevations of Original East Span Marine Foundations

Pier Number	Mudline Elevation (feet)	Required Removal Elevation (1.5 feet below mudline) (feet)	Planned Removal Limits (3 feet below mudline) (feet)
E6	-40.0	-41.5	-43.0
E7	-28.0	-29.5	-31.0
E8	-19.0	-20.5	-22.0
E9	-17.5	-19.0	-20.5
E10	-18.0	-19.5	-21.0
E11	-14.0	-15.5	-17.0
E12	-14.0	-15.5	-17.0
E13	-14.0	-15.5	-17.0
E14	-15.0	-16.5	-18.0
E15	-12.5	-14.0	-15.5
E16	-12.5	-14.0	-15.5
E17	-12.5	-14.0	-15.5
E18	-12.5	-14.0	-15.5

Note:
All elevations use National Geodetic Vertical Datum 1929
Source: Department 2016; compiled by AECOM in 2016

Piers E6 to E18 are cellular concrete structures that are supported by timber piles and concrete foundations. The pier foundations are made up of untreated Douglas fir timber piles, driven into the Bay mud. A concrete seal was poured on top of these piles, and a reinforced concrete slab was set on that seal. On top of their concrete slabs, Piers E6 to E18 support cellular concrete piers. Piers E6 to E8 and E10 to E18 each have two hollow concrete pedestals that are connected to the steel tower legs of the superstructure. A central reinforced concrete chamber connects the two pedestals. The structural designs for these piers generally are the same (Figure 5). Dimensions for Piers E6 to E18 are shown in Table 3.



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

Figure 5. Typical Schematic for Piers E6 to E8 and E10 to E16

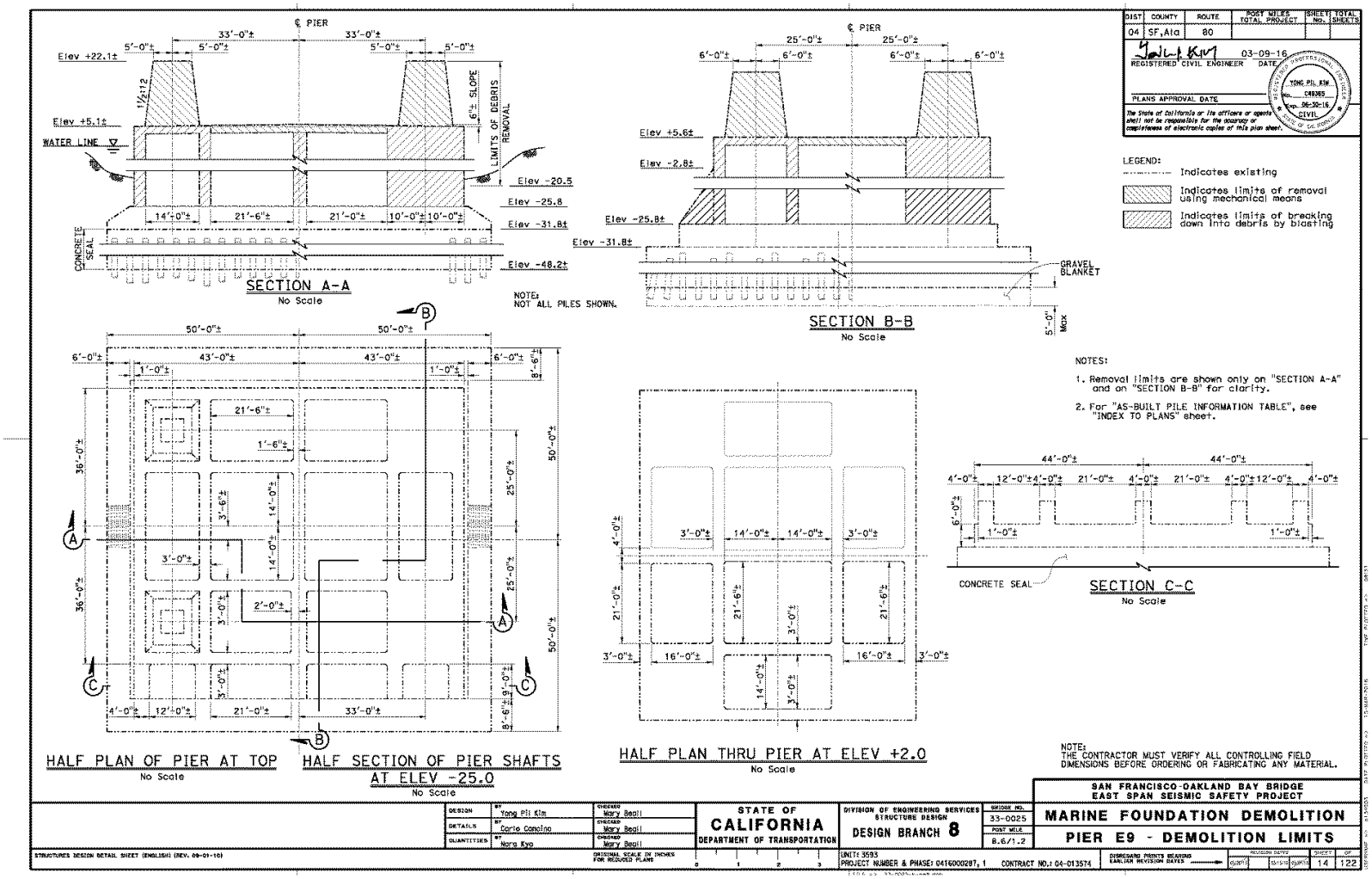
Pier E9 is a larger variant of the design used for the other timber pile-supported piers, and it has the greatest footprint and total volume of concrete of the timber pile-supported piers. On top of its concrete slab is a reinforced cellular structure, incorporating four solid concrete pedestals connected to the four legs of the steel tower. Pier E9 contains eight cellular chambers. On its west end, Pier E9 has five buttress walls (Figure 6).

The concrete pedestals of Piers E17 and E18 are taller than those of the other piers, and they connect directly to the truss spans that they support (Figure 7).

Table 3. Approximate Dimensions of Original East Span Marine Foundations

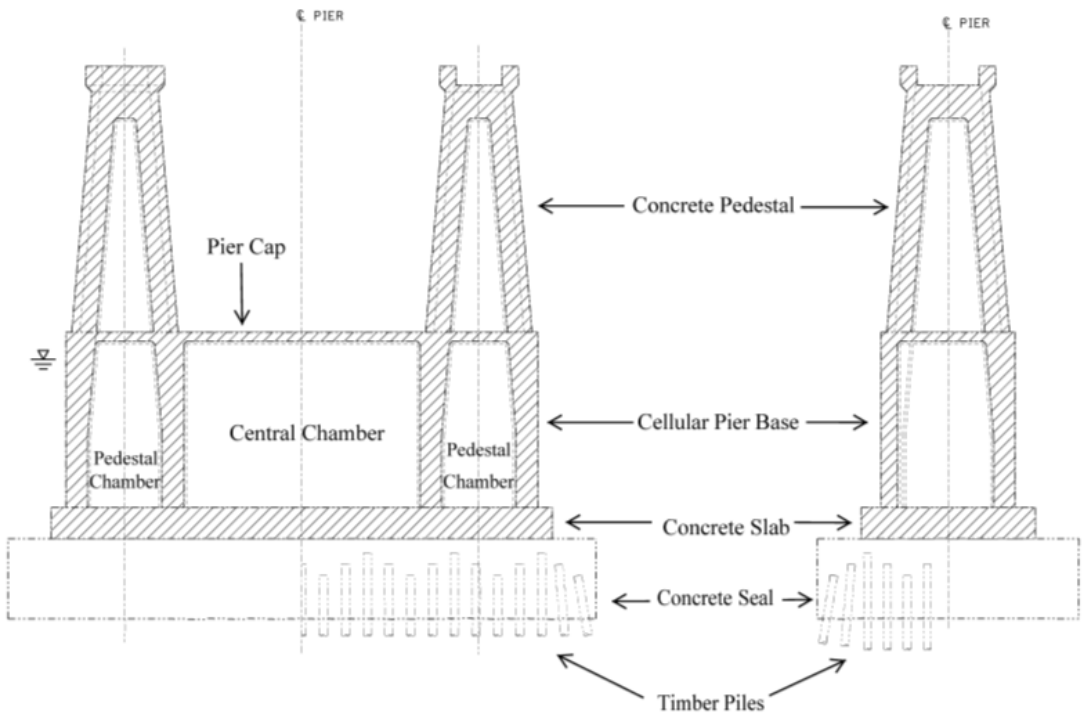
Pier Number	Structural Element											
	Concrete Seal			Concrete Slab			Hollow Pier			Pedestal		
	Length (feet)	Width (feet)	Height (feet)	Length (feet)	Width (feet)	Height (feet)	Length (feet)	Width (feet)	Height (feet)	Base Length (feet)	Base Width (feet)	Height (feet)
E6	128	68	18	108	48	6	90	30	34	20.5	16.5	17
E7	128	68	18	108	48	6	90	30	34	20.5	16.5	17
E8	128	68	18	108	48	6	90	30	34	20.5	16.5	17
E9	100	100	16	88	81	6	86	72	31.5	16	12	17
E10	112	44	16	96	27	5	90	21	32	15	12	17
E11	108	48	16	92	31	5	86	25	32	19	14	17
E12	108	44	16	91	27	5	74	21	32	15	12	17
E13	108	44	16	91	27	5	74	21	32	15	12	17
E14	108	44	16	91	27	5	84	21	32	15	12	17
E15	108	44	16	91	27	5	84	21	32	15	12	17
E16	108	44	16	91	27	5	84	21	32	15	12	17
E17	108	48	16	92	32	6	88	26	31	24	16.5	45
E18	108	48	16	92	32	6	88	26	31	24	16.5	37

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



Source: Department 2016

Figure 6. Removal Plan Sheet for Pier E9



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

Figure 7. Typical Schematic for Piers E17 and E18

1.2.3. Dismantling of Piers E6 to E18

Each pier will be removed following the same five steps:

- Remove the pier cap and concrete pedestals;
- Drill bore holes into the marine foundation;
- Install and test the BAS;
- Install charges, activate the BAS, and implode the pier; and
- Manage and remove remaining dismantling debris.

Steps to remove the marine foundations will include dismantling the concrete pedestals and concrete pier cap by mechanical means (including the use of torches and excavators mounted with hoe rams, drills, saws and cutting tools) to an approximate elevation of +9 feet NGVD29, and drilling vertical boreholes where the charges will be loaded for controlled blasting. 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 maximum charge weight per delay will be 35 pounds (16 kilograms). The entire detonation sequence for each pier is expected to last

approximately 1 to 4 seconds, depending on the pier being removed. The controlled blast removals have been designed to remove each pier to a minimum 3 feet (1 meter) below the average mudline elevation that occurs outside each pier's scoured pit.

To minimize impacts on biological resources in the Bay, a BAS will be installed around the base of the pier. The BAS is specifically designed to minimize noise and pressure effects that are generated by a controlled implosion.

Mechanical Dismantling of Concrete Pedestals and Pier Caps

For all piers, support barges will be used to move hydraulic excavators equipped with hoe rams, shearing attachments, drills, saws, and other equipment, including cutting lances and torches to be used during the mechanical dismantling. A barge-mounted crane will be used to move equipment onto and off each pier.

For all piers, the concrete pedestals and pier cap will be removed by mechanical means, using tools including those listed above to break the concrete structure into pieces. Concrete rubble and rebar will be managed using excavators and cranes that will be mounted with buckets. Throughout concrete dismantling operations on each pier, support platforms will be installed to provide a working surface for the excavators to dismantle the upper portion of the pier. The support platforms will be made up of timber crane mats. A debris catchment system, accepted by the San Francisco Regional Water Quality Control Board, will be in place to contain concrete debris from discharging into the Bay during dismantling operations.

For Piers E6 to E18, all concrete rubble from mechanical dismantling of concrete pedestals will be taken off-site for disposal. Rubble will be loaded onto receiving barges. The barges will be moved to Berth 9 in the Port of Oakland, where the concrete rubble and rebar will be removed from the barges onto land, to be sorted and disposed at an approved upland facility. The pier caps covering the central chambers of these piers will be dismantled last. They will be broken with a ram hoe and will remain in the hollow void during the controlled blasting.

During mechanical dismantling, the Department will monitor nesting birds and water quality, as required, and will employ best management practices to prevent inadvertent discharges into the Bay.

Drill Boreholes

After the mechanical dismantling operations are completed, access platforms will be installed on top of each pier to support the drilling equipment. The exposed interior cell

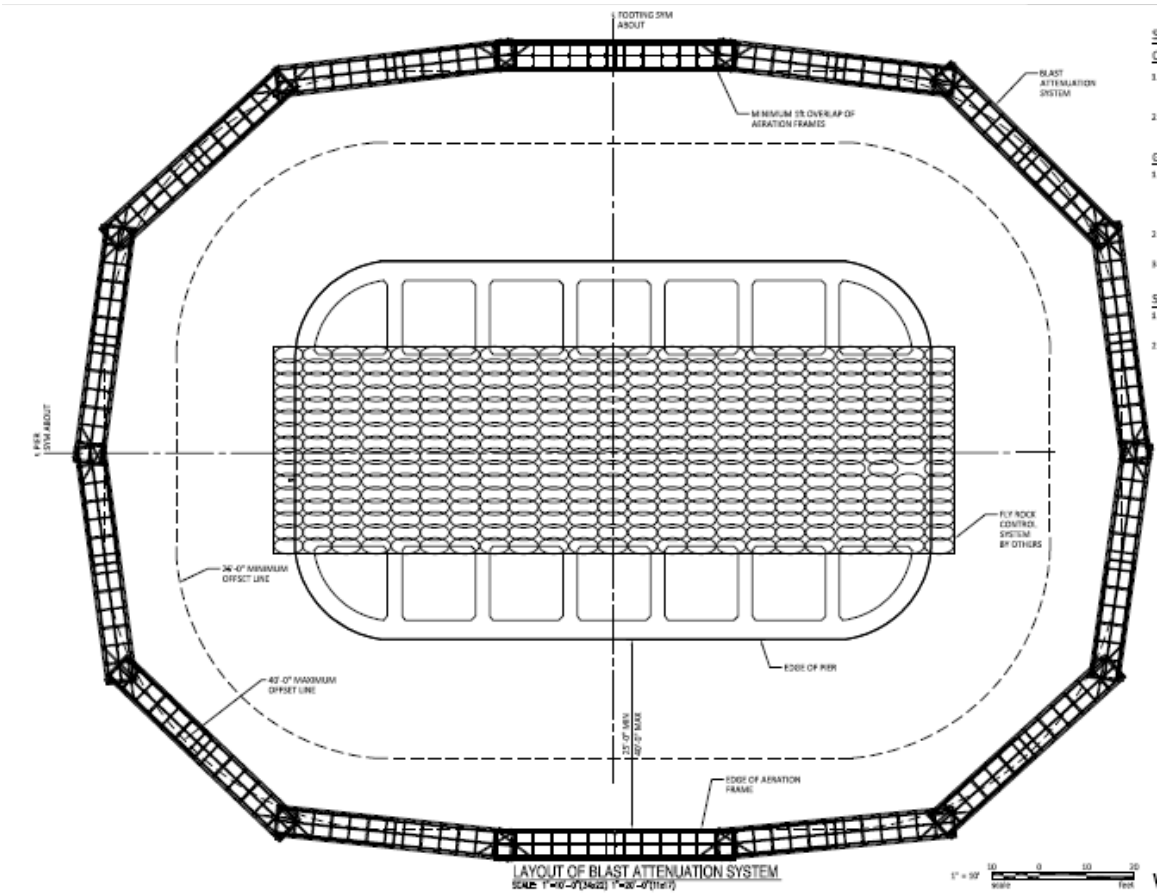
walls, buttress walls, and outside walls will be drilled from the top down, to remove concrete and create boreholes to just below the controlled blasting removal limit for each pier. Boreholes that are drilled in areas that are inundated with water (i.e., to the buttress walls and concrete slabs) will be done using a drill bit working within a tubular casing for guidance and to provide containment during in-water work. Monitoring will be performed to minimize and avoid impacts on water quality during this activity.

Drilling holes for underwater buttress walls on Pier E9 will be done by the same method that was used for the buttress wall of Pier E3. Divers will cut notches into the buttress walls and will install conduit to the work platform on top of the pier. The drilling will be done within the casings from the work platform.

Blast Attenuation System Installation and Deployment

The BAS that will be used at Piers E6 to E18 is the same system that was used successfully for the implosion of Piers E3, E4, and E5. 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. The BAS will be activated before and during implosion. As shown during previous pier implosion, the BAS will help minimize noise and pressure waves generated during each controlled blast, to minimize potentially adverse effects on biological resources. Each BAS frame is approximately 50.5 feet (15.4 meters) long by 6 feet (1.8 meters) wide. The BAS to be used at Piers E6 to E18 will be same system that was used at Piers E3, E4, and E5, and will meet the same specifications. An individual BAS will be installed around each pier included in a multiple pier implosion event. The complete BAS will be installed and tested during the weeks leading up to each controlled blast. Before installing the BAS, the Department will move any existing debris on the Bay floor that may interrupt proper installation of the BAS. Existing debris identified as a risk to proper installation of the BAS will be moved outside the path of the BAS layout. Each BAS frame will be lowered to the bottom of the Bay by a barge-mounted crane and positioned into place. Divers will be used to assist frame placement, and to connect air hoses to the frames. The BAS layout used during the implosion of Pier E3 is shown in Figure 8. A similar BAS layout will be used during the implosions of Piers E6 to E18. Based on location around the pier, the BAS frame elements will be situated from approximately 25 feet (7.6 meters) to 40 feet (12 meters) from the outside edge of the pier. Frames will be situated to contiguously surround the pier. 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. System performance is

anticipated to provide approximately 70 to 80 percent sound pressure attenuation, based on the results from previous controlled blasting activities.



Source: Kiewit 2015

Figure 8. BAS Layout Used during the Implosion of Pier E3 in November 2015

Test Blasts

At the beginning of the implosion season test blasts will be conducted within the completely installed and operating BAS so that the hydroacoustic monitoring equipment will be properly triggered and functional before the pier implosion events. A key requirement of the 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 blast on the same day may be required, to verify proper instrument operation and calibrate the equipment for the implosion event. 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 implosions.

Test charges will be scheduled to occur within two weeks of the first implosion scheduled for the implosion season and after the BAS is positioned into place and is functional. Additional test blasts many be needed prior to subsequent implosion events to ensure triggering of the data acquisition and recording instruments, as well as, calibration of the equipment. The BAS will be in operation during all tests. Tests will use a charge weight of approximately 18 grains (0.0025 pound) or less. The test charge will be placed along one of the longer faces of the pier and inside the BAS while it is operating. 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 Implosion of Remaining Pier Structures

Before pier removal via controlled blasting, the bore holes in the pier will be loaded with controlled charges. Individual cartridge charges, using electronic blasting caps versus pumpable liquid blasting agents, 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 will break the concrete efficiently 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 pier. Individual charge weights will vary from 20 to 35 pounds (9 to 16 kilograms), and the total charge weight for each controlled blast event will be approximately 2,132 to 15,800 pounds (5,000 to 5,500 kilograms). Depending on the location, size, and removal limit of the pier to be removed, the total number of individual charges to be used will range from approximately 100 to 455. The 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 will allow more efficient transfer of energy into the structural concrete for fracture, and will further reduce the release of potential energy into the surrounding water column. The entire detonation sequence, consisting of approximately 100 to 455 detonations, will last approximately 1 to 4 seconds for each pier; with a minimum delay time of 9 milliseconds (msec) between detonations.

Controlled blasting of Pier E6 will remove concrete by blasting down through the concrete slab and the top 3 feet (1 meter) of the concrete seal. Controlled blasting of Pier E7 will remove concrete by blasting down through the concrete slab but not the concrete seal. Controlled blasting of Piers E8 to E18 will remove concrete 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. For Pier E6, site conditions will require that the pier be blasted further into the structure, to remove the upper 3 feet (1 meter) of the concrete seal and remove the structure to the approved removal elevation. The remaining concrete seal and timbers will not be removed.

Through analysis and agency consultation, the Department determined that to minimize impacts on biological resources, controlled implosion events should be conducted at slack tides between September and November.

Multiple Pier Implosion Scenarios

To remove the 13 marine foundations of Piers E6 to E18 in 2017, multiple pier implosions may be performed on the same day, sequentially. Smaller piers will be combined into single blast events. The implosion of each pier within the blast events will be spaced 1 to 5 seconds apart. All pier implosion events involving multiple piers will use fewer explosives and will have a shorter total blast duration than the previous implosion of Pier E3. The approximate total explosive weight required to implode each pier is shown in Figure 9. The approximate blast duration for each pier is shown in Figure 10.

Up to two piers that formerly supported the either the 504-foot or 288-foot spans of the bridge may be imploded on the same day. Two to four small piers that formerly supported the 288-foot spans of the bridge may be imploded on the same day. A total of five to six pier implosion events, consisting of the implosion of one to four piers, may be required to remove Piers E6 to E18.

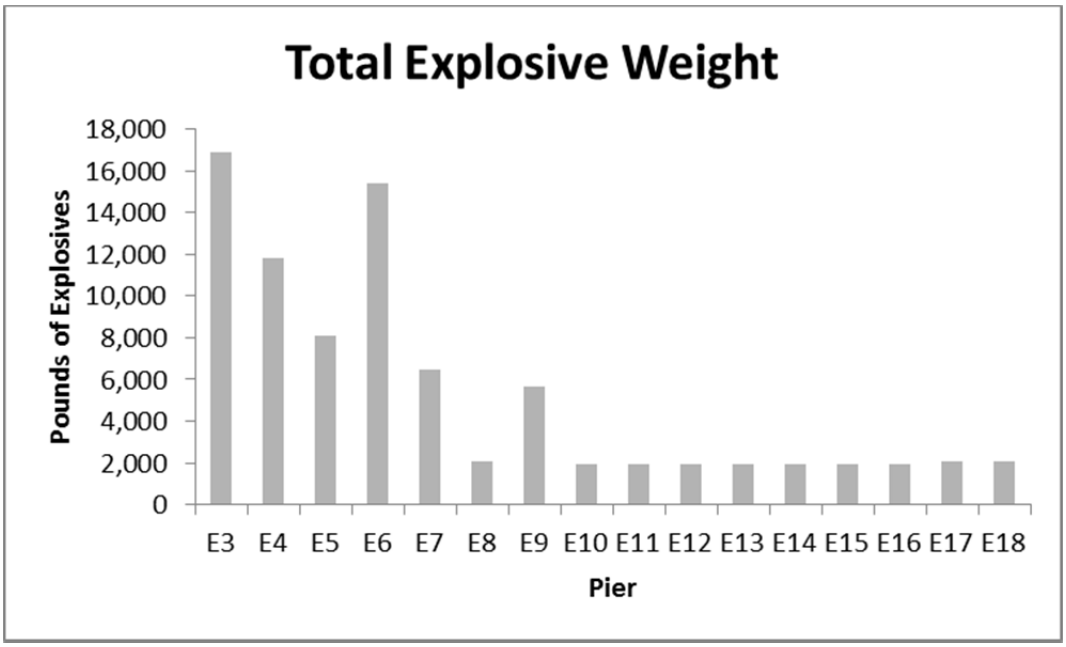
Pier E6 is the largest of the remaining piers and will be imploded individually, on a separated day from other pier implosions. The individual implosion of Pier E6 will require a similar quantity of explosives and similar blast duration as the previous implosion of Pier E3.

Debris Removal and Site Restoration

Following the controlled implosion event and confirmation that the area is safe for work, construction crews will begin to remove all associated equipment, including barges, compressors, the BAS, and blast mats. The Department expects that a small portion of rubble from each pier will fall outside its respective footprint and/or mound within the footprint of each pier, and will need to be managed after each controlled implosion. The portions of each pier that do not break apart during controlled blasting and remain above the removal limits will be demolished by mechanical means. This may require the use of

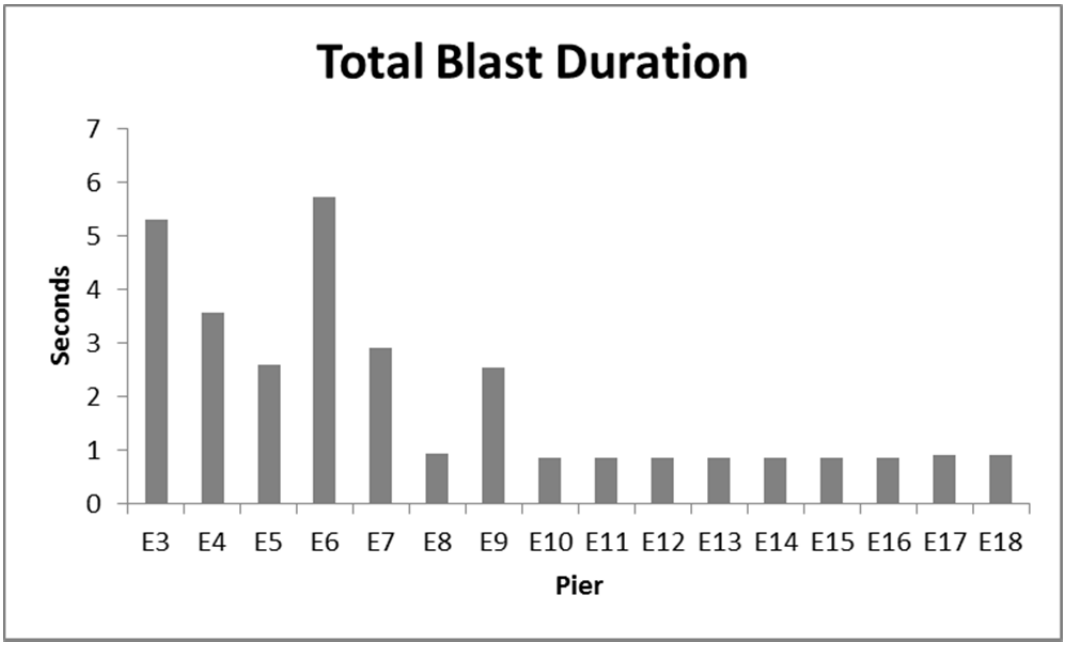
underwater mechanical equipment, including hydraulic crushing or grinding machinery or diver-operated jackhammers.

Rubble from the controlled blasting of Piers E6 to E18 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. The planned debris removal limit elevations are shown in Table 2. The clean-up and in-water site management operations are expected to take a few weeks, following each implosion event, and are anticipated to be completed by the end of December 2017.



Source: Department 2016

Figure 9. Approximate Total Explosive Weight per Pier



Source: Department 2016

Figure 10. ApproximateTotal Blast Duration per Pier

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 pile driving activities and implosion of Piers E4 and E5, was issued on September 19, 2016, and it will expire on September 18, 2017.

The Department is requesting issuance of a new IHA for a 1-year period. The first pier implosion event is scheduled for September 1, 2017. 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 July 15, 2017.

The controlled implosion events schedule for 2017 will take place at Piers E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, and E18 (Figure 11).

Source: ESRI 2015 (imagery); compiled by AECOM in 2016

Figure 11. Bridge Spans and Piers E6 to E18 Relative to Marine Mammal Feeding Areas and Haul-Out Site

Chapter 3. Species and Numbers of Marine Mammals

Seven species of marine mammals regularly inhabit or seasonally enter the San Francisco Bay (Table 4). 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 is observed near the Golden Gate, near Marin County and the city of San Francisco on the northwest side of the Bay, and rarely occur near the SFOBB east span, on the eastern side of the Bay. 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 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 4).

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 9 harbor porpoises were observed in the vicinity of the SFOBB east span (Department 2001, 2004b, 2013b, 2013c, 2014, 2015b, 2016, 2017).

Table 4. 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	12,844 648,534	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)	2,826	Stable
Steller Sea Lion *Eumetopias jubatus*	Eastern (California Haul-out Sites)	Threatened (ESA) Strategic (MMPA) Depleted (MMPA)	2,781	Increasing (Stable in California)
Short-Beaked Common Dolphin *Delphinus delphis delphis*	California/Oregon/Washington	Not Listed	411,211 (CV= 0.21)	Increasing
Fin Whale *Balaenoptera physalus physalus*	California/Oregon/Washington	Endangered (ESA) Strategic (MMPA) Depleted (MMPA)	3,051 (CV=0.18)	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	478 (CV=1.36)	Unknown
Sperm Whale *Physeter macrocephalus*	California/Oregon/Washington	Endangered (ESA) Strategic (MMPA) Depleted (MMPA)	971 (CV=0.31)	Unknown

Note:
CV = Coefficients of Variation; FESA = Federal Endangered Species Act; MMPA = Marine Mammal Protection Act
Sources: Carretta et al. 2015; 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 3,281 feet (1,000 meters) 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 180 feet (55 meters) from the piles, it abruptly turned around and dove (Department 2004b). Otherwise, most seals or sea lions were observed at least 328 feet (100 meters) beyond the pile driving activities. When an animal transited through the area, it typically looked toward the piles but 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 984 feet (300 meters) 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 San Francisco Bay (Figure 11) (Department 2004b).

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 section is shown in Table 5.

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. 2013), 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 2015). The population size for the California stock during the last count in 2012 was estimated at 30,968 seals (CV=0.157; Carretta et al. 2015).

Distribution: Harbor seals are found from Baja California to the eastern Aleutian Islands of Alaska. They primarily haul out on remote mainland and island beaches and reefs, and estuary areas. Harbor seals tend 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 the 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 the autumn, from late October through early December.

Table 5. 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 Bay	All Seasons	March-June (In SF Bay)	3 to 10 minutes (max of 30 min)	1-60 kHz (32 kHz)	1	YBI (4,593 feet; 1,400 meters)
California Sea Lion	Up to 2,000	Throughout Bay	All Seasons More In Summer - Winter	May-July (not SF Bay)	3-7 minutes (max of 10 min)	1-40 kHz (2-16 kHz)	1	Pier 39 (3.3 miles; 5.7 kilometers)
Northern Elephant Seal	Up to 100 (stranded juveniles)	Throughout Bay	Spring to Fall	December-March	10-15 minutes (max of 45 min)	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	Fall to Spring	May-October	3-7 minutes (max of 10 min)	1-40 kHz (2-16 kHz)	1	Mostly stranded, some haul out on YBI and TI
Common Bottlenose Dolphin	Occasional	Mostly 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	Western and Northern Bay	All Seasons	Spring (not SF 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 Bay	Late Winter to Spring	Winter (not in SF Bay	Short Dives	100 Hz-4 kHz	1-2	N/A
Source: see species description Sections 4.1–4.7								

Harbor seals tend to forage at night and haul out during the day. Harbor seals predominately haul out from 10 a.m. to 7 p.m., with a peak in the afternoon between 1 p.m. 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 south side of YBI, approximately 5,250 feet (1,600 meters) from Pier E6 and approximately 9,190 feet (2,800 meters) 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 have 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 has increased (8 days of monitoring and 95 sightings). Foraging near the project area is 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 occurs in a shallow trench area southeast of YBI (Department 2013a, 2013b). These sites are over 3,000 to 5,000 feet (900 to 1,525 meters) 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. Much of the harbor seal sightings are of 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 would 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. 2012), 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. 2015).

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 to be transiting mainly 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 the 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. 2013), or listed as endangered or threatened under the FESA. The population size for the California breeding stock is estimated at 179,000 seals and is increasing (Lowry et al. 2010, 2014; Carretta et al. 2015).

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 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 San Francisco 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. 2016). 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. 2012), 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 648,534 (Carretta et al. 2016). 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 San Francisco Bay. The Marine Mammal Center (MMC) 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, but most

are between 66 and 460 feet (20 and 140 meters) (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 size for the California coastal stock was estimated at 453 dolphins (CV= 0.06) in 2004/2005 (Carretta et al. 2016; 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 with El Niño events and increased ocean temperatures. An offshore 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 San Francisco Bay in 2010 (Szczepaniak 2013). Most bottlenose dolphins in the Bay have been observed in the western Bay, from the Golden Gate Bridge to Oyster Point and Redwood City, although one individual has been observed frequently near the former Alameda Air Station (Perlman 2017). The limited number of bottlenose dolphins visiting the east Bay makes it unlikely that the species will be exposed to the SFOBB Project's implosion activities.

Diving Behavior: Navy bottlenose dolphins have been trained to reach maximum diving depths of about 984 feet (300 meters) (Ridgway et al. 1969). Reeves et al. 2002) noted that the presence of deep-sea fish in the stomachs of some individual offshore bottlenose dolphins suggests that they dive to depths of more than 1,638 feet (500 meters). 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, midwater 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. 2013), or listed as endangered or threatened under the FESA. The population size for the San Francisco–Russian River stock is estimated at 9,886 porpoises (CV= 0.51) and is increasing (Carretta et al. 2014; Forney et al. 2013).

Distribution: This species is seldom 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 San Francisco 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. Harbor porpoises have been observed only on six occasions (all single animals or one mother with calf), swimming near the SFOBB east span. Those observations were made in the spring to early fall and occurred near YBI (May to October) (Department 2013c, 2014, 2015b). Rather than a pod of porpoises entering the project area, only single porpoises apparently move through the area, possibly searching for prey before returning to the pod. The rare occurrences of harbor porpoises near the SFOBB east span make it unlikely that any individuals will be exposed to SFOBB Project implosion activities.

Diving Behavior: Harbor porpoise are generally shallow, short duration divers. A study which evaluated the dive duration and depth of 2,878 dives made by a free-swimming harbor porpoise found that 90 percent of dives were within the upper 32 feet (10 meters) of the water column and 80 percent were less than one minute in duration (Otani et al

2000). In Canadian waters, the maximum dive depth reported was 676 feet (206 meters) 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 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 size for the eastern north Pacific stock is estimated at 20,990 (CV=0.71) (Durban et al. 2013) and has been stable since the 1990s (Carretta et al. 2015).

Distribution: The eastern North Pacific population of gray whales ranges from the south 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 west 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 coast of California during the migration south.

SFOBB Project Area: Reports from the MMC, the Sea Training Institute, the Oceanic Society, Richmond Bridge seal monitors, and local news reports 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 3,000 feet (914 meters) 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 164 to 197 feet (50 to 60 meters) 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 1,640 feet (500 meters) 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 west 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 46- to 72-foot depth (14 to 22 meters). 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 13 to 59 feet (4 to 18 meters).

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)

The southern sea otter (*Enhydra lutris*) is protected under the MMPA and is listed as threatened under the FESA (Carretta et al. 2012). The estimated population size is 3,054 sea otters (Tinker and Hatfield 2015). 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)

The 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 whales are listed as endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 1,729 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. The most recent occurrence was in 2007, when an injured mother and calf entered the Bay for 7 days (Gulland et al. 2008).

4.8.3. Guadalupe Fur Seal

The 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 seals are 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)

The 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 whales are not listed as threatened or endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 478 whales

(CV = 1.36) (Carretta et al. 2012). 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)

The 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 whales are 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)

The 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 whales are listed as endangered under the FESA. The current best estimate for the California, Oregon, and Washington stock is 3,051 whales (CV = 0.18) (Carretta et al. 2014). 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)

The 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 lions is no longer listed as threatened under the FESA (NOAA 2013). The current best estimate for the Eastern stock is 60,131 to 74,448 sea lions, with most of the population in southeast Alaska and British Columbia (Allen and Angliss 2015). From 1982 to 2009, the population of Steller sea lions using central California (Año Nuevo and the Farallon Islands) was relatively stable or slowly decreasing, to approximately 2,781 in 2011 (Allen and Angliss 2013). 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)

The 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 dolphins are not listed as threatened or endangered under the FESA. The short-beaked common dolphin is the most abundant cetacean in California waters, although the species tends to be found further offshore. The current best estimate for the California, Oregon, and Washington stock is 411,211 dolphins (CV =0.21) (Carretta et al.

2012). 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 dismantling activities for the removal 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 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 which has the potential to injure a marine mammal is defined further as Level A harassment. Harassment which 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 E6 to E18

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 6). 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:

<u>Peak pressure level</u>

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

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

SEL

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

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

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

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 6, 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 E6 to E18. 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 E6 to E18.

5.1. 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.

5.1.1. 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 (reviewed by Southall et al. 2007).

Table 6. 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:

Cumulative Sound Exposure Level (SEL_{cum})

Pascal-second (Pa-sec)

MF, HF, PW and OW associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function. Sources: Finneran and Jenkins 2012; NMFS 2016

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 United States 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 root-mean-square (RMS) re 1 μPa (Finneran et al. 2003). Although noise was not necessarily a factor, harbor seals abandoned a haul-out site after being repeatedly disturbed by small boats (Allen et al. 1984).

5.1.2. 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.

5.1.3. 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 75.5 feet (23 meters) of a 24.25-pound (11-kilogram) submerged dynamite charge (peak pressure of 530 pounds per square inch [psi] [252 dB re 1 μPa; reported in 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) (reported in 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).

Chapter 6. Take Estimates for Marine Mammals

The distance to marine mammal threshold criteria for underwater blasting activities and corresponding zones of influence (ZOI) have been determined based on underwater sound and pressure measurements collected during pervious pier implosion activities in the project area. 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 San Francisco Bay. Therefore, the in-water densities of harbor seals, California sea lions, and harbor porpoises were calculated based on 16 years of observations during monitoring for the SFOBB construction and demolition. 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 251 days of monitoring from 2000 through 2016 (including 15 days of baseline monitoring in 2003), 958 harbor seals, 80 California sea lions, and 9 harbor porpoises were observed in waters in the project vicinity. In 2015 and 2016, the number of harbor seals observed in the project area increased significantly and may be related to increases in water temperature (blob) and changes in prey abundance and distribution. Therefore, a harbor seal density estimate also was calculated for 2015–2016, which may better reflect the current use of the project area by harbor seals.

Density estimates for the elephant seal were made from stranding data, provided by the MMC. Insufficient sighting data exist to estimate the density of bottlenose dolphin. However, a single bottlenose dolphin has been observed regularly near the SFOBB east span. Also, 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.

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, outside the Piers E6 to E18 hydroacoustic zone) 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 seals sighting in the project area increased up to 41 seals (Department 2015b, 2016). Calculated harbor seal density (Table 7) is a per day estimate of harbor seals in a 1 square kilometer area during the fall/winter or spring/summer season.

Table 7. Estimated In-Water Density of Marine Mammals in the SFOBB Project Area

Species	Main Season of Occurrence	Density (animals/square kilometer)
Pacific Harbor Seal	Spring–Summer (pupping/molt seasons)	0.32
Pacific Harbor Seal	Fall–Winter	0.89
Pacific Harbor Seal 2015-2016	Fall-Winter	4.1
Northern Elephant Seal	Late Spring–Early Winter	0.03
California Sea Lion	Late Summer–Fall (post breeding season)	0.09
California Sea Lion	Late Spring–Early Summer (breeding season)	0.04
Northern Fur Seal	Late Fall-Early Spring	Insufficient Data Exists
Bottlenose Dolphin	Year Round	Insufficient Data Exists
Harbor Porpoise	Year Round	0.021
Gray Whale	Late Winter and Spring	0.00004
Gray Whale	Late Fall-Early Winter	Insufficient Data Exists

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 2016. Elephant seal densities are estimated from sighting and stranding data from the MMC.

A second set of Pacific harbor seal densities were calculated from the increase in sightings recorded during 2015 to 2016.

Insufficient sighting data exist to estimate bottlenose dolphin. However, a single animal has been regularly observed near the SFOBB east span.

Insufficient sighting data exist to estimate northern fur seal densities in the Bay. Approximately 2 to 4 strandings occur in the entire Bay per year, and they are unlikely to occur in the SFOBB project area.

Gray whale densities for late winter and spring are estimated from sighting and stranding data from the MMC. Insufficient sighting data exist to estimate gray whale densities for late fall to early winter in the Bay.

Sources: Department 2001, 2004b, 2013b, 2013c, 2014, 2015b, 2016, 2017; Perlman 2017; Compiled by BioMaAS 2017

Harbor seal density was calculated from all observations during SFOBB Project monitoring from 2000 to 2016, with a second set of density estimates for 2015–2016. These observations included data from baseline, pre-, during and post-pile driving, mechanical dismantling, on-shore blasting, and off-shore implosion activities. 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 and 2016, and therefore a separate density was calculated based on the 2015–2016 data. All harbor seal observations within a 1-square kilometer area were used in the estimate. Distances were recorded using a laser range finder (Bushnell Yardage Pro Elite 1500; ± 1.0 yard accuracy). 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 in a 1 square kilometer area during the fall/winter or spring/summer season (Table 7).

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, in the water can vary greatly, 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 2016. 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 within a 1-square kilometer area were used in the estimate. Distances were recorded using a laser range finder (Bushnell Yardage Pro Elite 1500; ± 1.0 yard accuracy). 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 in a 1 square kilometer area during the fall/winter or spring/summer season (Table 7).

6.1.3. Northern Elephant Seal Density Estimates

Northern elephant seal density in the project area was calculated from the stranding records of the MMC, from 2004 to 2014. These data included both injured or sick seals and healthy seals. Approximately 100 elephant seals were reported in the Bay during this time; most of these hauled out and likely were sick or starving. The actual number of individuals in the Bay may have been higher because not all individuals necessarily hauled out. Some individuals may have simply left the Bay soon after entering because the Bay is not a usual haul-out area for elephant seals. Data from the MMC show several elephant seals stranding on Treasure Island, and one healthy elephant seal was observed resting on the beach in Clipper Cove in 2012. Juvenile elephant seals may have stranded after they returned to California in the fall (September through November).

6.1.4. Northern Fur Seal Density Estimates

Too few observations or strandings of northern fur seals have occurred to determine density. The Marine Mammal Center reported only two to four northern fur seal strandings in the Bay in 2015 and 2016 (Marin, San Francisco and Santa Clara) (MMC 2017). That number is likely to decrease because the El Niño and warm water blob that affected the species' food resources has dissipated.

6.1.5. Common Bottlenose Dolphin Density Estimates

Too few observations of bottlenose dolphins have occurred to determine density. 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. One individual has been observed regularly near Alameda and likely passed by the project area, but no other reports of bottlenose dolphins exist in the project area (Perlman 2017).

6.1.6. Harbor Porpoise Density Estimates

Harbor porpoise density was calculated from all observations during SFOBB Project monitoring, from 2000 to 2016. 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 16 years of monitoring in the project area, only nine harbor porpoises were observed, and all occurred between 2006 and 2015 (including two in 2014 and five in 2015). All harbor porpoise observations within a 1 square kilometer area were used in the estimate.

Distances were recorded using a laser range finder (Bushnell Yardage Pro Elite 1500; ± 1.0 yard accuracy).

6.1.7. Gray Whale Density Estimate

Gray whale density was estimated for the entire Bay because no observations of gray whales have occurred in the project area. Each year, two to six gray whales enter the Bay, presumably to feed, in late winter through spring (February through April), per the MMC. Therefore, for late winter through spring, a density of 0.00004 gray whales per 1 square kilometer was used for the calculations. Gray whales rarely occur in the Bay from October through December. Insufficient sighting data exist for late fall through early winter to estimate gray whale densities. 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. Therefore, the analysis of take of gray whales from the scheduled pier implosion is not discussed further.

6.2. Implosion of Piers E6 to E18

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 6). Hydroacoustic monitoring was performed during the implosions of Piers E3, E4, and E5. Hydroacoustic monitoring results from these piers' implosion events are provided in Appendix B.

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 6). The estimated mass of the juveniles (6 to 16 months old) of each species was used in the lung injury and mortality calculations, because these would be the smallest animals potentially to be exposed to the implosions of Piers E6 to E18 in September, October, and November (Table 8). The depth at which the animal is exposed also affects the criterion threshold calculation. The area around Piers E6 to E18 is relatively shallow, at 10 to 40 feet (3 to 12 meters), and marine mammals traveling through the area surface frequently. Therefore, an average depth of 20 feet (6 meters) was used in the threshold calculation.

Table 8. Mass and Depth Ranges Used in the Calculation of Gastro-Intestinal Injury, Lung Injury and Mortality Criteria Thresholds.

Species	Age	Mass	Depth
Harbor Seal	5–7 months	66 pounds (30 kilograms)	20 feet (6 meters)
California Sea Lion	17–18 months	66 pounds (30 kilograms)	20 feet (6 meters)
Northern Elephant Seal	9–10 months	155 pounds (75 kilograms)	20 feet (6 meters)
Northern Fur Seal	4-12 months	33 pounds (15 kilograms)	20 feet (6 meters)
Harbor Porpoise	5–7 months	44 pounds (20 kilograms)	20 feet (6 meters)
Bottlenose Dolphin	6-12 months	155 pounds (75 kilograms)	20 feet (6 meters)

Note:
Baro-trauma increases with smaller size; therefore, the mass of juvenile animals was used to estimate criteria thresholds.
Source: CMS 2015

The Department has decided to use hydroacoustic monitoring results from the implosions of Piers E3, E4, and E5 to calculate distances to marine mammal thresholds for the implosions of Piers E6 to E18 (Department 2015a, 2016). Distances to marine mammal threshold criteria were calculated for the five anticipated pier implosion scenarios:

1. Implosion of Pier E6 (Tables 9 and 10),
2. Implosion of two 504-foot span piers in one pier implosion event (Tables 11 and 12),
3. Implosion of two 288-foot span piers in one pier implosion event (Tables 13 and 14),
4. Implosion of three 288-foot span piers in one pier implosion event (Tables 15 and 16), and
5. Implosion of four 288-foot span piers in one pier implosion event (Tables 17 and 18).

The methods used to calculate distances SEL_{cum} thresholds for the implosion of multiple piers are provided in Appendix C.

Table 9: Calculated Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS for Implosion of Pier E6

Species Hearing Group		Behavioral	TTS[1]		PTS[1]	
Mid-Frequency Cetaceans	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Isopleth Distance	1,330 feet	180 feet	**881 feet**	98 feet	**256 feet**
High-Frequency Cetaceans	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Isopleth Distance	12,567 feet	3127 feet	**8,358 feet**	1697 feet	**2,459 feet**
Phocid Pinnipeds	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Isopleth Distance	2,220 feet	613 feet	**1,484 feet**	332 feet	**443 feet**
Otariid Pinnipeds	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Isopleth Distance	554 feet	147 feet	**367 feet**	80 feet	**106 feet**

Note:
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: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 10: Calculated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Pier E6

Species		GI Tract		Lung	Mortality
Bottlenose Dolphin	Threshold	237 dB Peak	104 psi	39.1 $(75kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 208 Pa-sec	91.4 $(75kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet
Harbor Porpoise	Threshold	237 dB Peak	104 psi	39.1 $(20\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 134 Pa-sec	91.4 $(20\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 313 Pa-sec
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet
Harbor Seal	Threshold	237 dB Peak	104 psi	39.1 $(30\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 153 Pa-sec	91.4 $(30\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 359 Pa-sec
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet
Elephant Seal	Threshold	237 dB Peak	104 psi	39.1 $(75\ kg)^{1/3}$ $(1+[6/10.081])^{1/2}$ = 208 Pa-sec	91.4 $(75\ kg)^{1/3}$ $(1+[6/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet
Sea Lion	Threshold	237 dB Peak	104 psi	39.1 $(25\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 144 Pa-sec	91.4 $(25\ kg)^{1/3}$ $(1+[6m/10.081])^{1/2}$ = 338 Pa-sec
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet
Northern Fur Seal	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
	Isopleth Distance	48 feet	48 feet	< 40 feet	< 40 feet

Threshold Source: Finneran and Jenkins 2012

Isopleth Distance Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 11: Calculated Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS for Implosion of Two 504-foot Span Piers

Species Hearing Group		Behavioral	TTS[1]		PTS[1]	
Mid-Frequency Cetaceans	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Isopleth Distance	1,055 feet	166 feet	**685 feet**	90 feet	**190 feet**
High-Frequency Cetaceans	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Isopleth Distance	10,300 feet	2,882 feet	**6,800 feet**	1,564 feet	**1,966 feet**
Phocid Pinnipeds	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Isopleth Distance	1,790 feet	565 feet	**1,186 feet**	306 feet	**333 feet**
Otariid Pinnipeds	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Isopleth Distance	421 feet	136 feet	**274 feet**	74 feet	**78 feet**

Note:
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: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 12: Calculated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Two 504-foot Span Piers

Species		GI Tract		Lung	Mortality
Bottlenose Dolphin	Threshold	237 dB Peak	104 psi	$39.1\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Porpoise	Threshold	237 dB Peak	104 psi	$39.1\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 134 Pa-sec	$91.4\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 313 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Seal	Threshold	237 dB Peak	104 psi	$39.1\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 153 Pa-sec	$91.4\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 359 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Elephant Seal	Threshold	237 dB Peak	104 psi	$39.1\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Sea Lion	Threshold	237 dB Peak	104 psi	$39.1\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 144 Pa-sec	$91.4\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 338 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Northern Fur Seal	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
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet

Threshold Source: Finneran and Jenkins 2012
Isopleth Distance Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 13: Calculated Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS for Implosion of Two 288-foot Span Piers

Species Hearing Group		Behavioral	TTS[1]		PTS[1]	
Mid-Frequency Cetaceans	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Isopleth Distance	798 feet	166 feet	**517 feet**	90 feet	**126 feet**
High-Frequency Cetaceans	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Isopleth Distance	7,700 feet	2,882 feet	**5,140 feet**	**1,564 feet**	1,493 feet
Phocid Pinnipeds	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Isopleth Distance	1,359 feet	565 feet	**900 feet**	**306 feet**	232 feet
Otariid Pinnipeds	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Isopleth Distance	304 feet	136 feet	**185 feet**	**74 feet**	52 feet

Note:
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: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 14: Calculated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Two 288-foot Span Piers

Species		GI Tract		Lung	Mortality
Bottlenose Dolphin	Threshold	237 dB Peak	104 psi	$39.1\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Porpoise	Threshold	237 dB Peak	104 psi	$39.1\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 134 Pa-sec	$91.4\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 313 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Seal	Threshold	237 dB Peak	104 psi	$39.1\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 153 Pa-sec	$91.4\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 359 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Elephant Seal	Threshold	237 dB Peak	104 psi	$39.1\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Sea Lion	Threshold	237 dB Peak	104 psi	$39.1\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 144 Pa-sec	$91.4\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 338 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Northern Fur Seal	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
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet

Threshold Source: Finneran and Jenkins 2012
Isopleth Distance Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 15: Calculated Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS for Implosion of Three 288-foot Span Piers

Species Hearing Group		Behavioral	TTS[1]		PTS[1]	
Mid-Frequency Cetaceans	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Isopleth Distance	920 feet	166 feet	**588 feet**	90 feet	**132 feet**
High-Frequency Cetaceans	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Isopleth Distance	9,403 feet	2,882 feet	**5,900 feet**	1,564 feet	**1,722 feet**
Phocid Pinnipeds	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Isopleth Distance	1,580 feet	565 feet	**1,045 feet**	**306 feet**	258 feet
Otariid Pinnipeds	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Isopleth Distance	339 feet	136 feet	**201 feet**	**74 feet**	52 feet

Note:
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: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 16: Calculated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Three 288-foot Span Piers

Species		GI Tract		Lung	Mortality
Bottlenose Dolphin	Threshold	237 dB Peak	104 psi	39.1 (75kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 208 Pa-sec	91.4 (75kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Porpoise	Threshold	237 dB Peak	104 psi	39.1 (20 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 134 Pa-sec	91.4 (20 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 313 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Seal	Threshold	237 dB Peak	104 psi	39.1 (30 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 153 Pa-sec	91.4 (30 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 359 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Elephant Seal	Threshold	237 dB Peak	104 psi	39.1 (75 kg)$^{1/3}$ (1+[6/10.081])$^{1/2}$ = 208 Pa-sec	91.4 (75 kg)$^{1/3}$ (1+[6/10.081])$^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Sea Lion	Threshold	237 dB Peak	104 psi	39.1 (25 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 144 Pa-sec	91.4 (25 kg)$^{1/3}$ (1+[6m/10.081])$^{1/2}$ = 338 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Northern Fur Seal	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
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet

Threshold Source: Finneran and Jenkins 2012
Isopleth Distance Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 17: Calculated Distances to Underwater Blasting Threshold Criteria for Level B Behavioral and TTS and Level A PTS for Implosion of Four 288-foot Span Piers

Species Hearing Group		Behavioral	TTS[1]		PTS[1]	
Mid-Frequency Cetaceans	Threshold	165 dB SELcum	224 dB Peak	170 dB SELcum	230 dB Peak	185 dB SELcum
	Isopleth Distance	920 feet	166 feet	558 feet	90 feet	132 feet
High-Frequency Cetaceans	Threshold	135 dB SELcum	196 dB Peak	140 dB SELcum	202 dB Peak	155 dB SELcum
	Isopleth Distance	9,935 feet	2,882 feet	6,590 feet	1,564 feet	1,917 feet
Phocid Pinnipeds	Threshold	165 dB SELcum	212 dB Peak	170 dB SELcum	218 dB Peak	185 dB SELcum
	Isopleth Distance	1,730 feet	565 feet	1,135 feet	306 feet	264 feet
Otariid Pinnipeds	Threshold	183 dB SELcum	226 dB Peak	188 dB SELcum	232 dB Peak	203 dB SELcum
	Isopleth Distance	349 feet	136 feet	204 feet	74 feet	52 feet

Note:
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: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

Table 18: Calculated Distances to Underwater Blasting Threshold Criteria for Level A GI Tract and Lung Injury and Mortality for Implosion of Four 288-foot Span Piers

Species		GI Tract		Lung	Mortality
Bottlenose Dolphin	Threshold	237 dB Peak	104 psi	$39.1\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Porpoise	Threshold	237 dB Peak	104 psi	$39.1\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 134 Pa-sec	$91.4\ (20\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 313 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Harbor Seal	Threshold	237 dB Peak	104 psi	$39.1\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 153 Pa-sec	$91.4\ (30\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 359 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Elephant Seal	Threshold	237 dB Peak	104 psi	$39.1\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 208 Pa-sec	$91.4\ (75\ kg)^{1/3}\ (1+[6/10.081])^{1/2}$ = 487 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Sea Lion	Threshold	237 dB Peak	104 psi	$39.1\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 144 Pa-sec	$91.4\ (25\ kg)^{1/3}\ (1+[6m/10.081])^{1/2}$ = 338 Pa-sec
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet
Northern Fur Seal	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
	Isopleth Distance	44 feet	44 feet	< 40 feet	< 40 feet

Threshold Source: Finneran and Jenkins 2012
Isopleth Distance Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017

6.2.2. Number of Marine Mammals, by Species, that May be Taken by Implosion of Piers E6 to E18

The number of marine mammals by species that may be taken by implosion of Piers E6 to E18 were calculated based on distances to the marine mammal threshold criteria, duration of the activity, and the estimated density of each species in the ZOI. Distances to marine mammal threshold criteria were calculated based on mean sound pressure levels anticipated to be generated during the implosions of Piers E3, E4, and E5. As a conservative measure, because of the variability in sound pressure levels from previous pier implosion events, the calculated distances to each of the marine mammal thresholds was increased by 20 percent (see Tables 23, 24, and 25).

For each pier implosion event, the total area of the criteria zone was calculated in ArcGIS and was multiplied by the density of each species. The area of criteria zones are graphically shown in Figures 12 through 21. The estimated in-water density of each species in the project is provided in Table 7. Because a marine mammal can be taken only once in a 24-hour period, the estimated exposures for the PTS zone were subtracted from the TTS zone exposures, and the TTS zone exposures were subtracted from the behavioral response zone exposures; therefore an animal was not counted as being exposed multiple times. For example, for the implosion of two 288-foot span piers the area of harbor seal PTS zone was calculated to be 0.0709 square kilometers, the area of the TTS zone was calculated to be 0.4279 square kilometers, the area of the behavioral zone was calculated to be 0.9071 square kilometer, and the harbor seal density was 4.1 seals/square kilometer. Therefore, 0.2908 seals (0.0709 square kilometers x 4.1 seals/square kilometer) may be exposed to sound levels that elicit PTS; 1.4636 seals ([0.4279 square kilometers x 4.1 seals/square kilometer] – 0.2908 seals) may be exposed to sound levels that elicit TTS; and 2.2553 seals ([0.9071 square kilometers x 4.1 seals/ square kilometer] – 1.4636 seals) may be exposed to sound levels that may elicit a behavioral response. Spreadsheets showing the calculations that were performed to estimate marine mammal exposures for each pier implosion scenario are provided in Appendix D.

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 each pier implosion scenario (Table 19). As shown by the estimated take numbers in Table 19, the more small piers that are imploded in a single implosion event, the fewer implosion events that will be required and fewer marine mammals will be exposed to sound pressure levels that can

Table 19. Estimated Exposures of Marine Mammals to Each Implosion Scenario for Levels B Behavioral Response and TTS Threshold Criteria.

Species	Pier E6		Two 504-foot Span Piers*		Two 288-foot Span Piers		Three 288-foot Span Piers		Four 288-foot Span Piers	
	Behavioral Response	TTS	Behavioral Response	TTS	Behavioral Response	TTS	Behavioral Response	TTS	Behavioral Response	TTS
Pacific Harbor Seal	5	4	4	3	2	1	3	2	4	3
California Sea Lion	0	0	0	0	0	0	0	0	0	0
Northern Elephant Seal	0	0	0	0	0	0	0	0	0	0
Northern Fur Seal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Harbor Porpoise	1	0	0	0	0	0	0	0	0	0
Bottlenose Dolphin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
Spreadsheets showing the calculations that were performed to estimate marine mammal exposures for each pier implosion scenario are provided in Appendix D.
With implementation of exclusion zones and delay procedures, no take by Level A is anticipated.
* These take numbers are applied to the implosion of two 504-foot span piers in the same blast event, the implosion of one 504-foot span pier and one 288-foot span pier in the same blast event, or the implosion of Pier E9 individually.
Source: Calculated by AECOM

result in Level B take. Take was calculated assuming a worst case scenario involving six (the maximum number of) pier implosion events. Based on the distances to the marine mammal threshold criteria and estimated species density, approximately 38 harbor seals (22 by behavioral response and 16 by TTS) may be taken by Level B harassment during the implosions of Piers E6 to E18 (Table 20); no take of any other species is anticipated.

Table 20. Combined Estimated Exposures of Marine Mammals to the Piers E6 to E18 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	22	16	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	0	0	0	0	0	0
Total	22	16	0	0	0	0

Note:
[1] No implosion would occur if any marine mammal is within the Level A or mortality threshold criteria zones.
Source: Calculated by AECOM

6.2.1. Species Impacts from the Implosion of Piers E6 to E18

Pacific Harbor Seal: Harbor seal will be the most vulnerable species to sounds or pressures originating from the implosions of Piers E6 to E18. It is the most numerous marine mammal in the Bay and most likely to be in the vicinity of Piers E6 to E18. However, most of the observations made during monitoring for the SFOBB Project have been of seals transiting through the area around Piers T1 to E5, near YBI and main navigation channel, rather than remaining there to forage. The exception is the new foraging area for young seals around Piers E2 to E5 of the new Bay Bridge, but that site is used only occasionally. Seals are less frequently observed in the shallow water areas near the Oakland shoreline. The Department anticipates less seals to be present near pier implosion sites as implosion events move closer to the Oakland shoreline

No harbor seals would be subject to GI track injury, lung injury, or mortality. The zones for these effects are within 48 feet (15 meters) of the pier. The BAS will be activated before pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 an 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 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 SFOBB construction has been ongoing since 2003, including the Pier E3 implosion in 2015, and Piers E4 and E5 in 2016, with continued use of the area by harbor seals.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria, the Department estimates that 39 harbor seals may be exposed to sound pressure levels that can result in Level B harassment (Table 20). Twenty-three of those exposures will be within the Level B behavioral response criteria threshold, and 16 will be within the TTS threshold criteria (Table 20). Two harbor seals are estimated to be exposed to SPLs that can result in Level A PTS take. However, because of the measures to be implemented before the controlled implosion of Piers E6 to E18, 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 vulnerable species to controlled implosion because it is the second most numerous marine mammal species in the Bay, after the harbor seal. California sea lions may occur in the vicinity of Piers E6 to E18 during the implosions, 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 48 feet (15 meters) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 SFOBB construction has been ongoing since 2003, including the implosions of Pier E3 in 2015, and Piers E4 and E5 in 2016, with continued use of the area.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria, the Department estimates that no sea lions will be exposed to the SPLs that could result in Level B harassment (Table 20). Because of the avoidance and minimization measures to be implemented before the controlled implosions of Piers E6 to E18, 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 Piers E6 to E18. 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 48 feet (15 meters) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 SFOBB construction has been ongoing since 2003, with limited, continued use of the area for transit or resting.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria, the Department estimates that no elephant seals will be exposed to SPLs that can result in Level B harassment (Table 20). Because of the avoidance and minimization measures that will be implemented before the controlled implosions, 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 Piers E6 to E18. 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 48 feet (15 meters) of the pier. BASs will be activated prior to pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 is not expected because SFOBB construction has been ongoing since 2003, with limited, continued use of the area.

Based on the small number, rare occurrence, and the distances to the marine mammal threshold criteria, the Department estimates that no fur seals will be exposed to SPLs that can result in Level B harassment (Table 20). Because of the avoidance and minimization measures that will be implemented before the controlled implosions, 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: Impacts on harbor porpoises are unlikely. This species rarely occurs in the vicinity of Piers E6 to E18. 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 48 feet (15 meters) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 implosions, it may be subject to slight inner ear injury (PTS). Behavioral responses of harbor porpoises 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 SFOBB construction has been ongoing since 2003, with limited, continued use of the area for transit or foraging.

Based on the calculated density estimates and the distances to the marine mammal threshold criteria, the Department estimates that no harbor porpoise will be exposed to SPLs that can result in Level B harassment (Table 20). 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: Impacts on bottlenose dolphins are unlikely. This species rarely occurs in the vicinity of Piers E6 to E18. 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 48 feet (15 meters) of the pier. BASs will be activated before pier implosion and will generate a bubble flux extending over 100 feet (30 meters) 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 implosions, 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 ever has occurred.

Based on the small number, rare occurrence, and the distances to the marine mammal threshold criteria, the Department estimates that no bottlenose dolphins will be exposed to SPLs that can result in Level B harassment (Table 20). 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.

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

The estimated number of marine mammals exposed to implosion SPLs for each threshold criteria (Table 20) are based on current density estimates of marine mammals in the project area (Table 7). 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 21).

Table 21. Amount of Level B Harassment Take of Marine Mammals Requested for the Implosions of Piers E6 to E18

Species	Level B Harassment Take[1]	
	Behavioral Response	Temporary Threshold Shift
Pacific Harbor Seal	66	48
California Sea Lion	18	12
Northern Elephant Seal	6	3
Northern Fur Seal	6	3
Harbor Porpoise	18	9
Bottlenose Dolphin	6	3
Total	120	78

Note:
1. Test blasts would be delayed if any marine mammals are detected within any of the Level A or mortality threshold criteria exclusion zones.

6.4. Test Blasts

In addition to the implosions of Piers E6 to E18, one to two test blasts may be conducted before the pier implosion events. 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 22 shows measured SPLs from the Pier E5 test blasts, compared to phocid and high-frequency cetacean threshold criteria, at a distance of 100 feet (30 meters) from the blast (just outside the BAS). 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 22. 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 100 feet (30 meters)
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 2016 a
Measured Test Levels Source: Appendix A

Chapter 7. The Anticipated Impact of the Activity

The numbers shown in Table 19 represent estimated exposures to each harassment threshold criteria zone under the MMPA. The threshold zones for the implosions of Piers E6 and E18 were calculated based on measurements collected during the implosions of Piers E3, E4, and E5.

Because of this analysis and through implementation of avoidance and minimization measures, the Department has determined that the controlled implosions of Piers E6 to E18 will result only in Level B harassment. Based on the best available science, exposures to marine mammal species and stocks from controlled implosions 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 16 years of previous SFOBB 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.

Chapter 8. The Anticipated Impacts on Subsistence Uses

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

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 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, and from clean-up 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. 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 8.7 miles (14 kilometers) 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 have the potential to injure or kill fish in the immediate area. During previous 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 population or their availability as a food resource for marine mammals.

Based on the discussion in this section, 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 E6 to E18 through controlled implosions is 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. 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) 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 near Piers E6 to E18 may be altered for a few hours after the implosion. These fish populations will be replenished as project activities cease and the local population mixes again.

Based 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 substantial loss of marine mammal habitat (i.e., no destruction of haul-out sites or destruction of important reef areas will occur). Therefore, no impacts will occur.

Chapter 11. Mitigation Measures

11.1. Minimization of Impacts from Implosion of Piers E6 to E18

The methods proposed to demolish Piers E6 to E18 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 E). 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 E6 to E18 are similar to those analyzed for Pier E3, and will 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 multiple smaller piers into single, sequential blast events will further reduce potential impacts on marine mammals. It 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 all piers during implosions. Based on the results of acoustic monitoring for the implosions of Piers E3, E4, and E5, 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 implosions of Piers E6 to E18, a project-specific monitoring plan (discussed further in Chapter 13) will be used 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 previously NMFS-approved Marine Foundation Removal Project Final Biological Monitoring Program that was implemented during the implosions of Piers E4 and E5. In particular, monitors will observe the MMEZ and will delay the implosions if any individuals are within this zone. The same procedure was implemented successfully for the implosions of Piers E3, E4, and E5, 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.

Chapter 12. Arctic Plan of Cooperation

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

Chapter 13. Monitoring and Reporting

A specific marine mammal monitoring plan for implosion of Piers E6 to E18 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 E4 and E5

The marine mammal monitoring plan for implosion of Piers E6 to E18 will be similar to the NMFS-approved marine mammal monitoring plans that were implemented for the implosions of Piers E3 to E5. 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 E6 to E18, based on conservatively estimated distances to acoustic threshold criteria, for anticipated pier implosion scenarios as follows:

1. Pier E6 blast event;
2. Blast event of two 504-foot span piers, or blast event of one 504-foot span pier and one 288-foot span pier, or Pier E9 blast event;
3. Blast event of two 288-foot span piers;
4. Blast event of three 288-foot span piers; and
5. Blast event of four 288-foot span piers.

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 implosions of Piers E3, E4, and E5 were used to calculate distances to these thresholds for the implosions of Piers E6 to E18, as discussed in Chapter 6 and shown in Tables 9 to 18. As a conservative measure, to ensure that no marine mammals are taken by Level A harassment, the field-implemented MMEZ will be 20 percent larger than the calculated distances to threshold criteria shown in Tables 9 to 18. This conservative measure will ensure that no marine mammals are taken

by Level A harassment, in the event that realized SPLs are greater than predicted by modeling.

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, plus an additional 20 percent conservative factor (Table 23, Figures 12, 13, 14, 15, and 16). The harbor porpoise exclusion zone will be established at the radial distance to the high-frequency cetacean PTS Level A harassment threshold, plus an additional 20 percent conservative factor (Table 23, Figures 17, 18, 19, 20, and 21).

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 implosions of Piers E3, E4, and E5 were used to calculate distances to these thresholds for the implosions of Piers E6 to E18, as discussed in Chapter 6 and shown in Tables 9 to 18. As a conservative measure, to ensure that marine mammal monitoring zones include all areas where SPLs may equal or exceed thresholds for Level B behavioral response and TTS, the field-implemented behavioral response and TTS monitoring zones will be 20 percent larger than the calculated distances to threshold criteria shown in Tables 9 to 18. This conservative measure will ensure that the monitoring zones will include all areas where SPLs may exceed thresholds for Level B harassment, in the event that realized SPLs are greater than predicted by modeling.

The isopleths for Level B harassment to phocid pinnipeds (harbor seal and elephant seal) for all pier implosion scenarios 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, plus an additional 20 percent conservative factor (Tables 24 and 25, Figures 12, 13, 14, 15, and 16).

Table 23. Marine Mammal Level A Exclusion Zones for Pier E6 to E18 Implosions

Pier Implosion Scenarios	Species / Group	Calculated Distances to Level A PTS Threshold	20 Percent Contingency Factor	Level A Injury and Mortality Exclusion Zone
Pier E6	Pinniped and Dolphin	443 feet (135 meters)	89 feet	**532 feet** (162 meters)
	Harbor Porpoise	2,459 feet (750 meters)	492 feet	**2,951 feet** (899 meters)
Two 504-foot Span Piers, or One 504-foot Span Pier and One 288-foot Span Pier, or Pier E9	Pinniped and Dolphin	333 feet (101 meters)	67 feet	**400 feet** (122 meters)
	Harbor Porpoise	1,966 feet (599 meters)	393 feet	**2,359 feet** (719 meters)
Two 288-foot Span Piers	Pinniped and Dolphin	306 feet (93 meters)	61 feet	**367 feet** (112 meters)
	Harbor Porpoise	1,564 feet (477 meters)	313 feet	**1,877 feet** (572 meters)
Three 288-foot Span Piers	Pinniped and Dolphin	306 feet (93 meters)	61 feet	**367 feet** (112 meters)
	Harbor Porpoise	1,722 feet (525 meters)	344 feet	**2,066 feet** (630 meters)
Four 288-foot Span Piers	Pinniped and Dolphin	306 feet (93 meters)	61 feet	**367 feet** (112 meters)
	Harbor Porpoise	1,917 feet (584 meters)	383 feet	**2,300 feet** (701 meters)
Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017				

Table 24. Marine Mammal Level B Behavioral Response Monitoring Zones for Pier E6 to E18 Implosions

Pier Implosion Scenarios	Species / Group	Calculated Distances to Level B Behavioral Response Threshold	20 Percent Contingency Factor	Level B Behavioral Response Monitoring Zones
Pier E6	Pinniped and Dolphin	2,220 feet (677 meters)	444 feet	**2,664 feet** (812 meters)
	Harbor Porpoise	12,567 feet (3830 meters)	2,513 feet	**15,080 feet** (4,596 meters)
Two 504-foot Span Piers, or One 504-foot Span Pier and One 288-foot Span Pier, or Pier E9	Pinniped and Dolphin	1,790 feet (546 meters)	358 feet	**2,148 feet** (655 meters)
	Harbor Porpoise	10,300 feet (3,139 meters)	2,060 feet	**12,360 feet** (3,767 meters)
Two 288-foot Span Piers	Pinniped and Dolphin	1,359 feet (414 meters)	272 feet	**1,631 feet** (497 meters)
	Harbor Porpoise	7,700 feet (2,347 meters)	1,540 feet	**9,240 feet** (2,816 meters)
Three 288-foot Span Piers	Pinniped and Dolphin	1,580 feet (482 meters)	316 feet	**1,896 feet** (578 meters)
	Harbor Porpoise	9,403 feet (2,866 meters)	1,881 feet	**11,284 feet** (3,439 meters)
Four 288-foot Span Piers	Pinniped and Dolphin	1,730 feet (527 meters)	346 feet	**2,076 feet** (633 meters)
	Harbor Porpoise	9,935 feet (3,028 meters)	1,987 feet	**11,922 feet** (3,634 meters)
Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017				

Table 25. Marine Mammal Level B TTS Monitoring Zones for Pier E6 to E18 Implosions

Pier Implosion Scenarios	Species / Group	Calculated Distances to Level B TTS Threshold	20 Percent Contingency Factor	Level B TTS Monitoring Zones
Pier E6	Pinniped and Dolphin	1,484 feet (452 meters)	297 feet	**1,781 feet** (543 meters)
	Harbor Porpoise	8,358 feet (2,548 meters)	1,672 feet	**10,030 feet** (3,057 meters)
Two 504-foot Span Piers, or One 504-foot Span Pier and One 288-foot Span Piers, or Pier E9	Pinniped and Dolphin	1,186 feet (361 meters)	237 feet	**1,423 feet** (434 meters)
	Harbor Porpoise	6,800 feet (2,072 meters)	1,360 feet	**8,160 feet** (2,487 meters)
Two 288-foot Span Piers	Pinniped and Dolphin	900 feet (274 meters)	180 feet	**1,080 feet** (329 meters)
	Harbor Porpoise	5,140 feet (1,567 meters)	1,028 feet	**6,168 feet** (1,880 meters)
Three 288-foot Span Piers	Pinniped and Dolphin	1,045 feet (318 meters)	209 feet	**1,254 feet** (382 meters)
	Harbor Porpoise	5,900 feet (1,798 meters)	1,180 feet	**7,080 feet** (2,158 meters)
Four 288-foot Span Piers	Pinniped and Dolphin	1,135 feet (346 meters)	227 feet	**1,362 feet** (415 meters)
	Harbor Porpoise	6,590 feet (2009 meters)	1,318 feet	**7,908 feet** (2,410 meters)
Sources: Calculated by Illingsworth & Rodkin, based on results presented in Department 2015a, 2016, and 2017				

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

Figure 12. Pinniped and Dolphin Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Pier E6

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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown. These isopleth also will be applied for implosion events made up of one 504-foot span pier and one 288-foot span pier, or implosion of Pier E9 individually.

Figure 13. Pinniped and Dolphin Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Two 504-foot Span Piers

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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

Figure 14. Pinniped and Dolphin Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Two 288-foot Span Piers

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

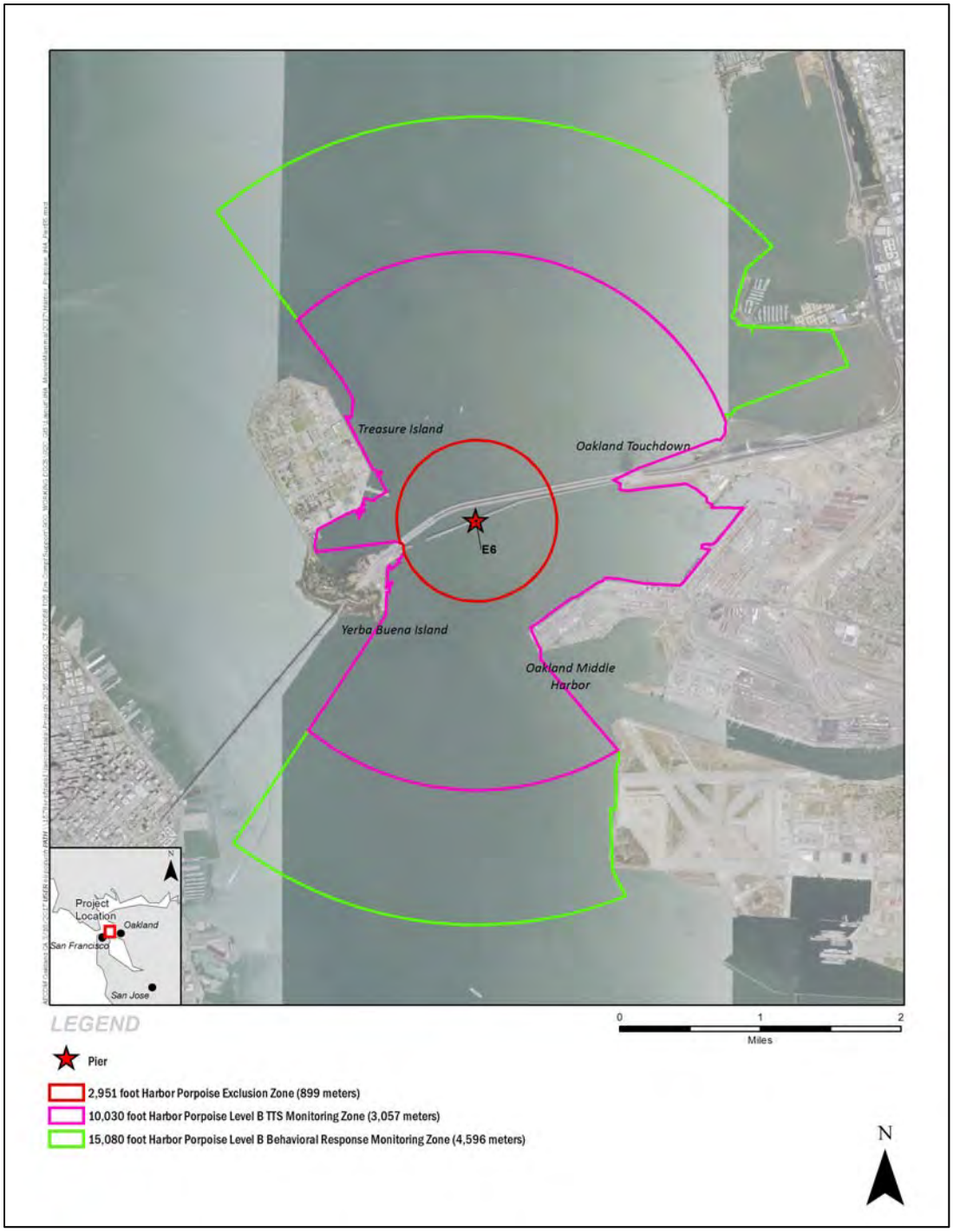
Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

Figure 15. Pinniped and Dolphin Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Three 288-foot Span Piers

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

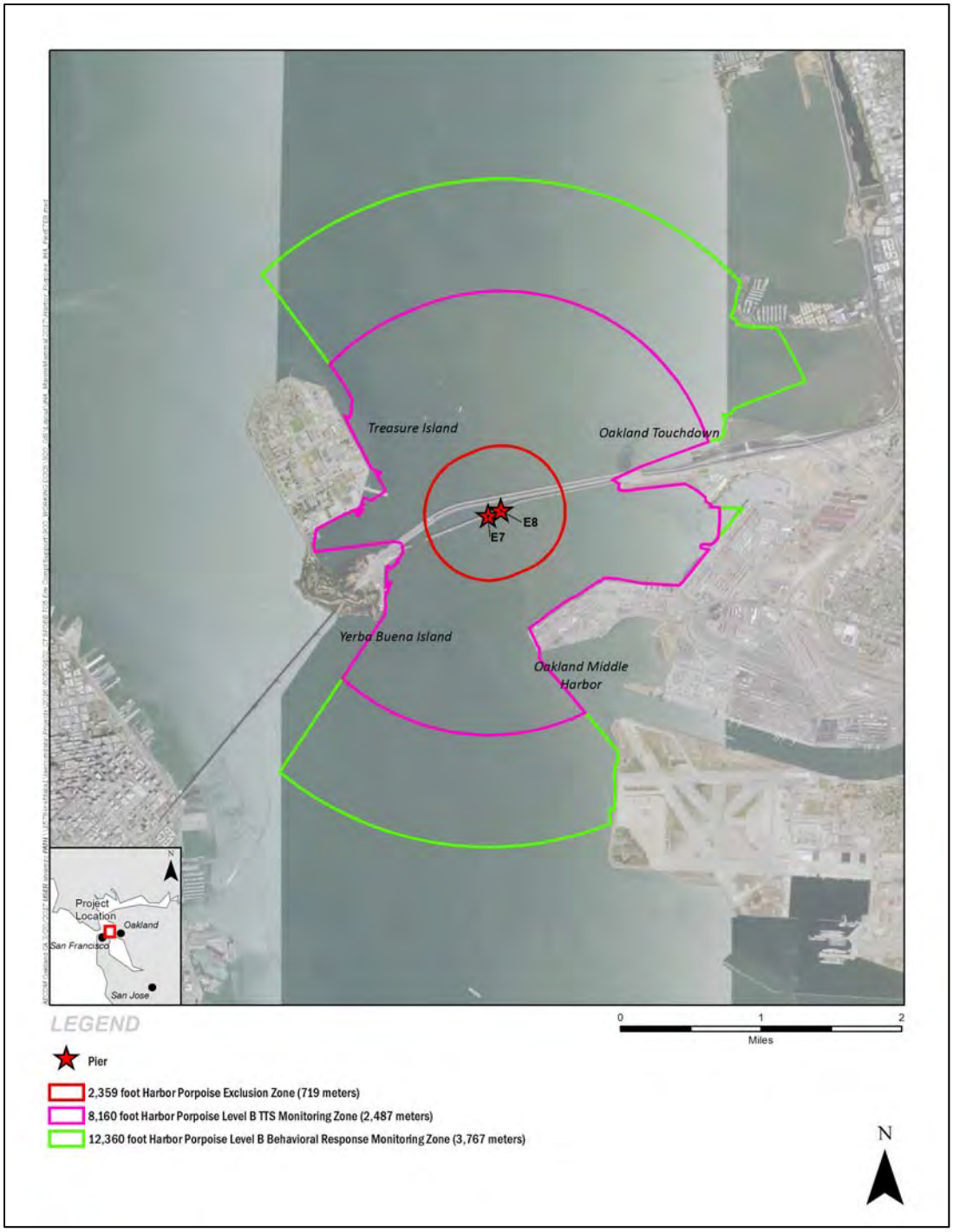
Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

Figure 16. Pinniped and Dolphin Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Four 288-foot Span Piers



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

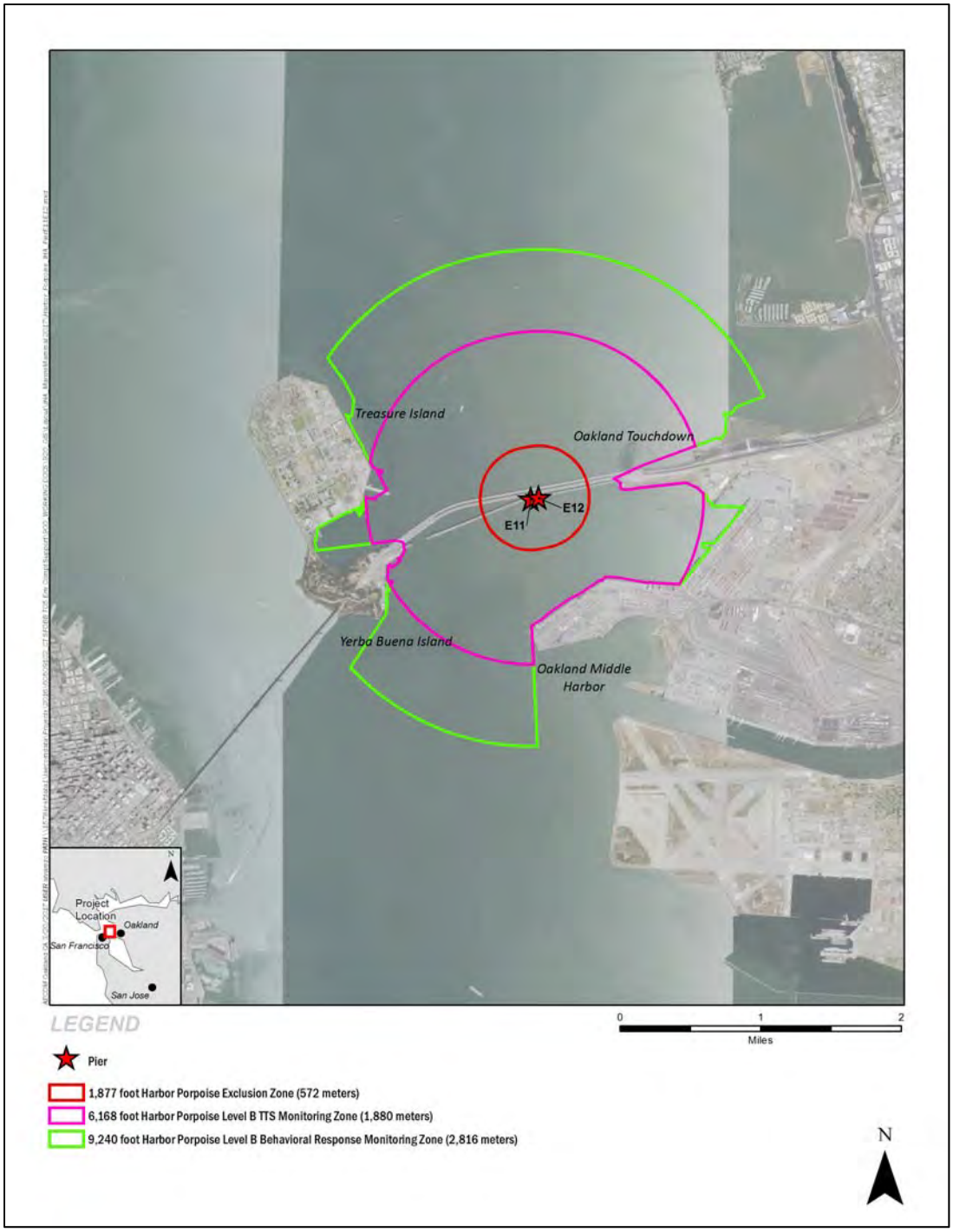
Figure 17. Harbor Porpoise Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Pier E6



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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown. These isopleth also would be applied for implosion events made up of one 504-foot span pier and one 288-foot span pier, or implosion of Pier E9 individually.

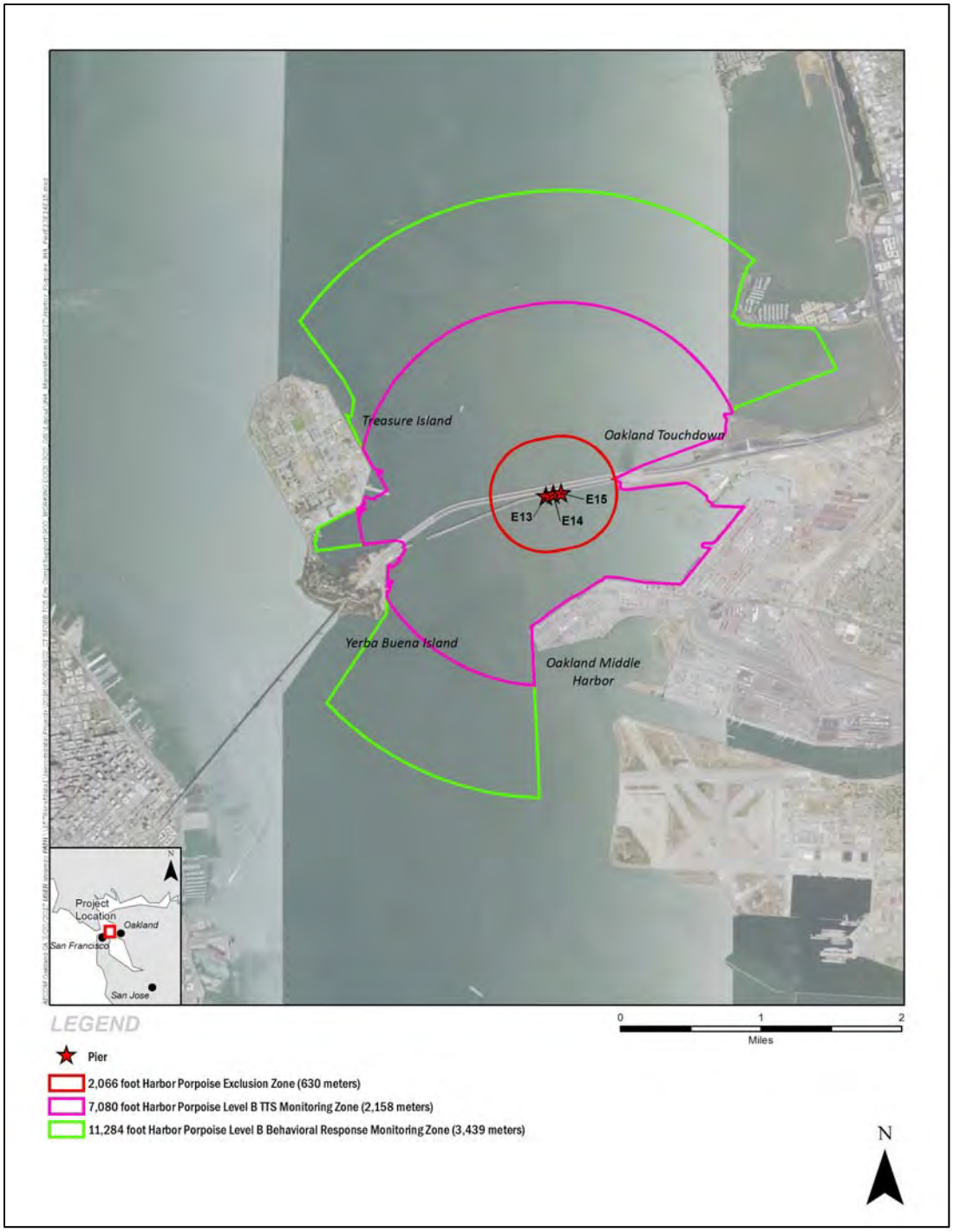
Figure 18. Harbor Porpoise Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Two 504-foot Span Piers



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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

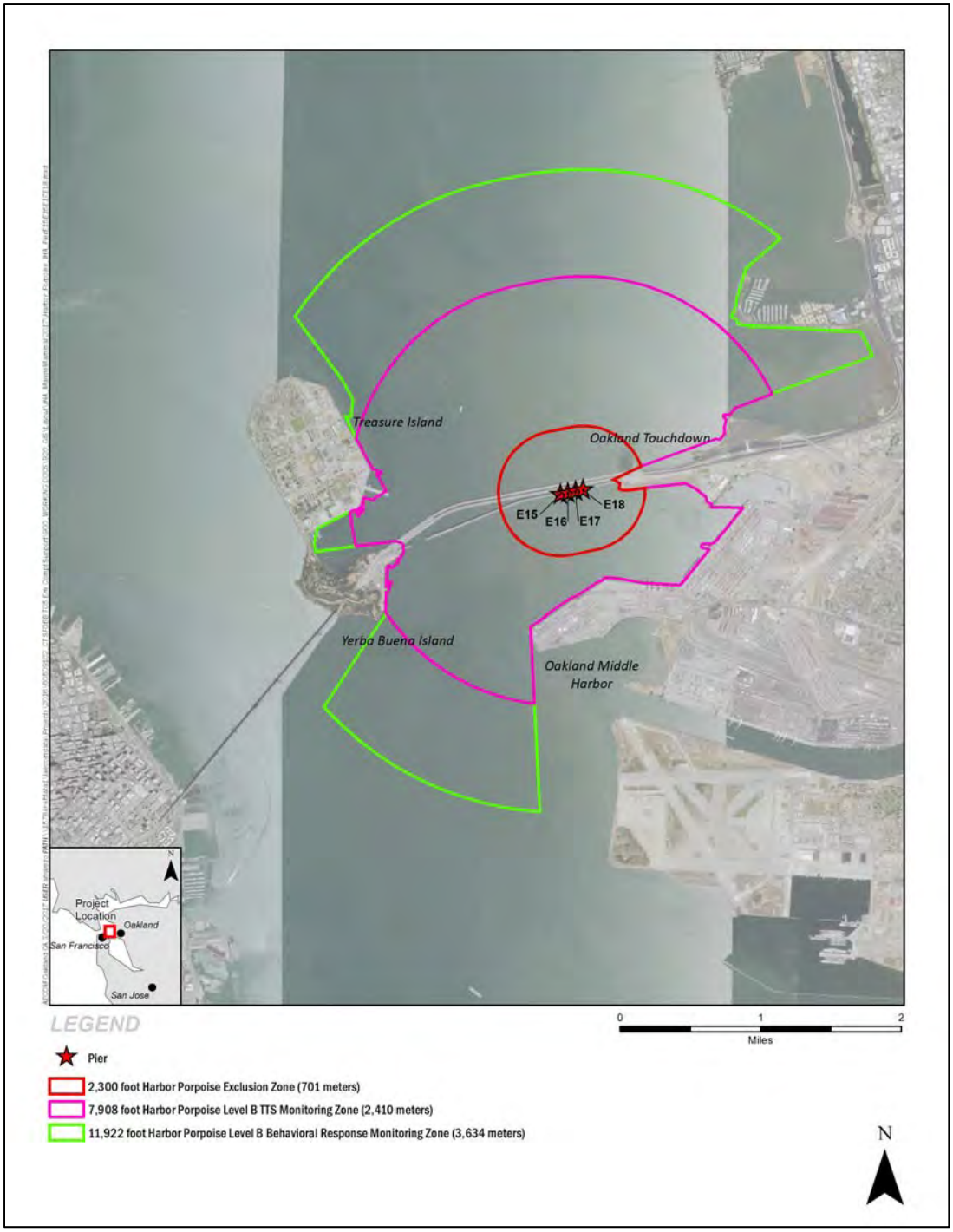
Figure 19. Harbor Porpoise Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Two 288-foot Span Piers



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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

Figure 20. Harbor Porpoise Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Three 288-foot Span Piers



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

Note: The pier implosion event shown is hypothetical. Which specific piers will be imploded together is unknown.

Figure 21. Harbor Porpoise Level A Injury Exclusion Zone and Level B Harassment Monitoring Zone for Implosion of Four 288-foot Span Piers

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, plus an additional 20 percent conservative factor (Tables 24 and 25, Figures 17, 18, 19, 20, and 21).

Marine Mammal Observers: A minimum of ten MMOs will be required during the implosions of Piers E6 to E18, so that the MMEZs and Level B harassment zones can be monitored. Up to 15 MMOs may be required for implosions events involving multiple piers. 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: Implosions of Piers E6 to E18 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 an 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 implosions of Piers E6 to E18 is very unlikely, boat or shore surveys will be conducted for 3 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.

13.2. 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.

13.3. Stranding Plan

A stranding plan for the implosions of Pier E3, E4 and E5 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 implosions of Piers E6 to E18. 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 Piers E6 to E18 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 3 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 was 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 to NMFS as soon as possible, followed by a written report within a month.

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. The MMC has provided us with annual data on marine mammal strandings in the Bay, to inform our analysis of potential takes from project activities. We also have worked in partnership with the MMC 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 the MMC, Long Marine Laboratory (University of California, Santa Cruz), and Moss Landing Marine Laboratory, and have assisted in population and radio telemetry studies in San Francisco 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 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.

Chapter 15. List of Preparers

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

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Preliminary Summary of Test Blast Results

Test blasts were conducted during a low slack tide on November 5, 2015 alongside Pier E3 in order to assess the measurement techniques to be used for hydroacoustic monitoring of the Pier E3 Demolition Implosion scheduled for November 14, 2015. The source was an 18 grain blasting cap positioned approximately 20 feet from Pier E3 at a depth of 20 feet below the surface. Illingworth & Rodkin, Inc. (I&R) monitoring locations were 20 feet and 75 feet away from the Pier and the blast, as illustrated in the sketch shown in Figure 1. The depths of both sensors were 20 feet below the water surface. The data acquisition systems were placed on the Pier and on the barge supporting the compressors used for the eastern half of the blast attenuation system (BAS). A third location was also monitored from the barge at the southwest corner, at a distance slightly more than 100 feet from the blast, at a depth of 20 feet. Two blasts were produced and monitored; one while the BAS was supplied with air at 30 psi and one approximately 20 minutes later while the BAS was supplied with air at 100 psi.

The peak sound pressure levels measured for the first blast are shown in Figure 2 superimposed on a photograph of the measurement set up as viewed from the barge. The results for both blasts are shown in Table 1. The modeled results for peak pressure and cumulative SEL are shown in Table 2. The reported values include the peak pressure level, the SEL, and the RMS level, as monitored at both the 20-foot and 75-foot distances. The levels at Location 3 (100 feet) were too low to be measured relative to the background noise due to the ambient and instrumentation noise. Ambient levels were measured to be approximately 140 dB at 20 feet, 119 dB at 75 feet, and 139 dB at 100 feet.

The levels at Location 1 (20 feet) were lower than expected; however, it appears that these measurements were actually made within the BAS bubble stream. The signals at this location were only slightly higher than the background ambient noise, and reported levels may be actually inflated by this background noise. The pressure signals at Location 2 (75 feet from Location 1) propagated more fully through the BAS and are significantly lower in level. The difference between Blast 1 and Blast 2 was different at Locations 1 and 2. Close to the blast at Location 1, the higher air pressure supplied during Blast 2 resulted in lower levels for all three metrics, as compared to Blast 1. At Location 2, the different metrics for Blast 2 ranged from slightly lower to slightly higher than Blast 1. The actual pressure versus time histories for Locations 1 and 2 were quite different on account of the differences in the metrics. Given that there are only two measurement locations, one being within the BAS and the other outside the BAS, a fall-off rate for these cannot be determined. When compared to the noise criteria established by the National Marine Fisheries Service, however, the levels at 75 feet are below the 206 dB peak pressure criteria for injury to all fish, below the 187 and 183 dB SEL criteria for injury to fish greater than and less than 2 grams, respectively, and below the 150 dB RMS criteria for behavioral response to fish.

Table 1: Test Blast Noise Levels

Pier E3 Data (20ft from Blast)			
Metric	Blast 1	Blast 2	Reference
Peak	207.1	201.9	dB re 1µPa
SEL	180.9	178.2	dB re 1µPa2-sec
RMS	192.6	189.2	dB re 1µPa

Barge Data (75ft from Blast)			
Metric	Blast 1	Blast 2	Reference
Peak	153.9	157.1	dB re 1µPa
SEL	136.4	135.9	dB re 1µPa2-sec
RMS	142.7	149.1	dB re 1µPa

Table 2: Predicted Peak Pressures by Distance

Criteria	
Distance	**PEAK Level**
20 feet from blast	235 dB
88 feet from blast	206 dB
100 feet from blast	205 dB

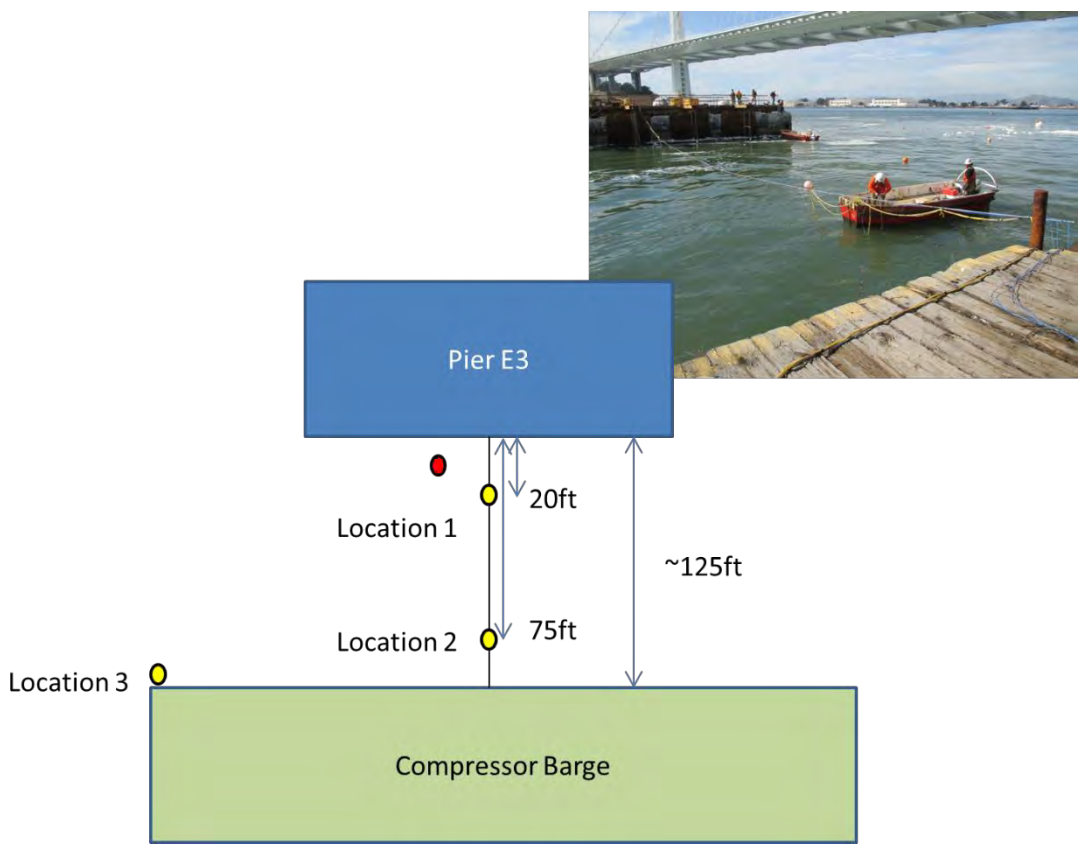

Figure 1: Test blast measurement geometry sketch

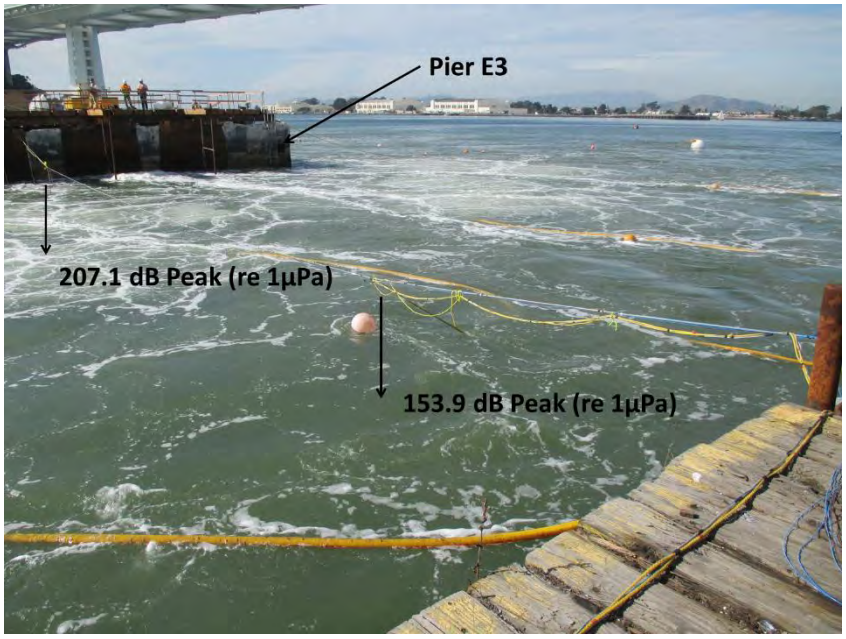

Figure 2: Photograph test blast measurement set up with peak pressure levels

Pier E5 Test Blast Results

Capturing the acoustic results of the implosion is a critical monitoring component to determine potential impacts on biological resources in the Bay. A key factor in accurately capturing hydroacoustic information was to ensure triggering of the data acquisition and recording instruments. The instruments used high-speed recording devices during near-field and far-field monitoring of the implosion. To this end, the pressure-time signature of a blast cannot be duplicated except with another blast. Thus, release of small test charges was required to verify and confirm that all equipment is functional and to set the triggering parameters accurately for the implosion.

The Department discharged two test charges at separate times within a single day of testing on Friday November 7, 2016, during separate events. These tests occurred while the BAS was in operation. The BAS was placed 50 feet from Pier E5 and pressure sensors were deployed at distances of 10, 20, 30, 80, and 100 feet from the single detonators, in north and west directions. All data were collected during low water slack tide. Monitoring at the 20 feet and 100 feet locations were used to analyze in-water noise/pressure levels during these test events (Figure 1).

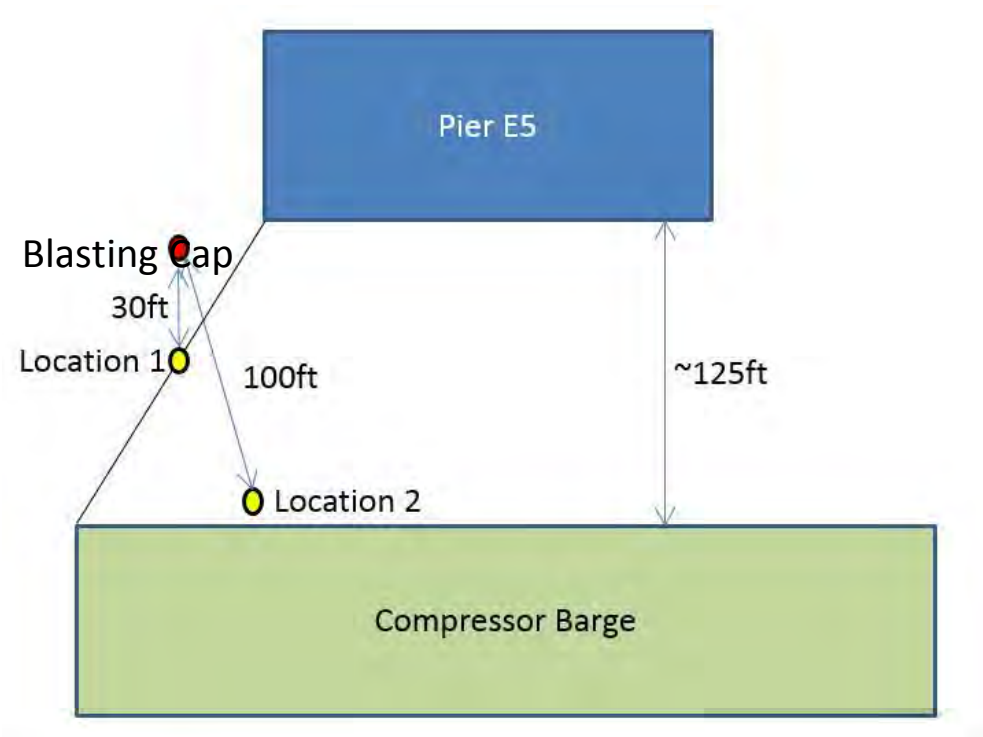

Figure 1. Pier E5 Test Blast Measurement Geometry Sketch

The depths of both sensors were 20 feet below the water surface. Autonomous recording systems were used to record the blasts, as well as ambient conditions. Location 1 was supported by a cable connecting the Pier to the barge, and Location 2 was connected to the barge used to support the compressors for the BAS. After the data were collected, it was later processed using a high-speed data acquisition system. Two blasts were produced and monitored: one at approximately 11:09 a.m. and the second at 11:47 a.m.

The same types of data acquisition systems used during the implosion of Piers E5 and E4 were deployed to monitor in-water pressure levels from the single detonator using pressure sensors and hydrophones. All equipment functioned as expected, and the 'break-wire' trigger method was successfully tested. Deployment methods were also deemed successful. Background levels were measured 100 feet from the pier with and without the BAS in operation. Without the BAS, the background levels were 116.6 dB, and background levels with the BAS in operation were 128.8 dB.

The results for both blasts are shown in Table 1. For the Pier E5 test blasts, the levels measured during the first blast were lower than the second blast. Given that there were only two measurement locations for each test blast, one being within the BAS and the other outside the BAS, a fall-off rate cannot be determined.

Table 1. Test Blast Noise Levels at Pier E5

Blast	Distance from Blast, feet	Peak, dB re 1μPa	SEL, dB re 1 μPa^2-sec	RMS, dB re 1μPa
Blast #1 (at 11:09 a.m.)	30 feet	187.3	164.0	169.2
	100 feet	150.6	133.8	139.1
Blast #2 (at 11:47 a.m.)	30 feet	199.8	178.1	183.4
	100 feet	157.1	139.7	145.0

Appendix B. Hydroacoustic Monitoring Results for the Implosions of Piers E3, E4, and E5

Hydroacoustic Monitoring Results
For Marine Mammal Criteria
From the Implosions of Piers E3, E4, and E5

In 2013, NMFS established sound threshold criteria for take of marine mammals from underwater blasting, based on Finneran and Jenkins 2012 (Table 1). Measured distances to marine mammal threshold criteria from the 2015 implosion of Pier E3 were used to conservatively estimate the distances to these threshold criteria for the 2016 implosions of Piers E4 and E5.

Table 1. Intermit Sound Threshold Criteria for Take of Marine Mammals from Underwater Blasting

		Behavior		Slight Injury			
Group	**Species**	**Behavioral (for ≥ 2 pulses/ 24 hours)**	**TTS**	**PTS**	**Gastro Intestinal Tract**	**Lung**	**Mortality**
Low-frequency Cetaceans	humpback whale	167 dB cSEL (LF_{II})	172 dB cSEL (LF_{II}) or 224 dB peak SPL	187 dB cSEL (LF_{II}) or 230 dB peak SPL	237 dB SPL or 104 psi	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
Mid-frequency Cetaceans	bottlenose dolphin	167 dB cSEL (MF_{II})	172 dB cSEL (MF_{II}) or 224 dB peak SPL	187 dB cSEL (MF_{II}) or 230 dB peak SPL			
High-frequency Cetaceans	harbor porpoises	141 dB cSEL (HF_{II})	146 dB cSEL (HF_{II}) or 195 dB peak SPL	161 dB cSEL (HF_{II}) or 201 dB peak SPL			
Pinnipeds -Phocidae	harbor seal and elephant seal	172 dB cSEL (P_{WI})	177 dB cSEL (P_{WI}) or 212 dB peak SPL	192 dB cSEL (P_{WI}) or 218 dB peak SPL			
Pinnipeds -Otariidae	sea lions and northern fur seal	195 dB cSEL (O_{WI})	200 dB cSEL (O_{WI}) or 212 dB peak SPL	215 dB cSEL (O_{WI}) or 218 dB peak SPL			

Notes:
All decibels are referenced to 1 micro Pascal (re: 1µPa).
dB = decibel(s); cSEL = cumulative sound exposure level; PTS = Permanent Threshold Shift; RMS = root mean square; SPL = sound pressure level; TTS = Temporary Threshold Shift
Source: Finneran and Jenkins 2012

Before the implosions of Piers E4 and E5, marine mammal Level A PTS exclusion zones and Level B TTS and behavioral monitoring zones were established based on measured distances to marine mammal threshold criteria from the 2015 implosion of Pier E3. For simplicity, a single Level A exclusion zone, a single Level B TTS monitoring zone, and a single Level B behavioral monitoring zone were established for all pinniped and dolphin species. The pinniped and dolphin exclusion and monitoring zones were based on measured distances to threshold criteria for phocids (Pacific harbor seal and northern elephant seal). The distances to the Level A and Level B threshold criteria for otariids (California sea lion and northern fur seal) and the mid-frequency cetacean (bottlenose dolphin) are less than the distance to the phocids (harbor seal and elephant seal) threshold criteria. The pinniped and dolphin exclusion and monitoring zones were established based on thresholds for phocids, shown in Table 1. Distances to these zones are shown in Table 2. The harbor porpoise exclusion and monitoring zones were established based on thresholds for high-frequency cetaceans, shown in Table 1. Distances to these zones are shown in Table 2.

Table 2. Marine Mammal Exclusion and Monitoring Zones

Species	Level A	Level B Monitoring Zones	
	Exclusion Zone	Temporary Threshold Shift	Behavioral Response
Pinnipeds and Dolphins (*harbor seal, sea lion, elephant seal, fur seal and bottlenose dolphin*)	507 feet (155 meters)	1,658 feet (505 meters)	2,460 feet (750 meters)
Harbor porpoise	1,777 feet (542 meters)	5,580 feet (1,701 meters)	8,171 feet (2,491 meters)

Notes:
1. Exclusion and monitoring zones are based on measured distances to threshold criteria for phocids (harbor seal and elephant seal) and high-frequency cetaceans (harbor porpoise) from the implosion of Pier E3 (Department 2015b).
2. The distances to the Level A and Level B threshold criteria for oteriids (sea lion and fur seal) and the mid-frequency cetacean (bottlenose dolphin) are less than the distance to the phocids (harbor seal and elephant seal) threshold criteria. Because the exclusion zones for oteriids and bottlenose dolphin would be in the near-field of the implosion and to simplify monitoring procedures, the Department elected to monitor a larger exclusion zone and Level B harassment monitoring zone for oteriids and bottlenose dolphin.

Source: Federal Register 2016

Hydroacoustic monitoring was conducted during the implosions of Piers E3, E4 and E5 to determine distances to all marine mammal underwater blasting threshold criteria for each of the blast events. Weighting factors for phocids, otariids, high frequency cetaceans (harbor porpoise), and mid frequency cetaceans (bottlenose dolphin) were subtracted from the measured cSEL values for each pier and compared to the established marine mammal criteria for the respective mammal groups. The results calculated for each pier are shown in Figure 1 for phocids, in Figure 2 for otariids, in Figure 3 for high frequency cetaceans, and in Figure 4 for mid frequency cetaceans. For Piers E4 and E5, the trend lines for all species fall below the Pier E3 trend line at

distances within 3,500 feet of the implosion. At distances beyond 3,500 feet, the trend line for Pier E5 is higher than all the others, but is well below impact criteria at that distance. The effect of the marine mammal weightings lowers the cSEL values compared to the unweighted values. This effect is relatively small for phocids and otariids (approximately 2 to 2.5 dB at 1,000 feet) and larger (approximately 17 dB at 1,000 feet) for high frequency cetaceans. The weightings increase with distance since the low frequency energy increases with distance. Therefore, fall-off rates for the weighted trend lines are slightly greater than the unweighted cSEL fall-off rates.

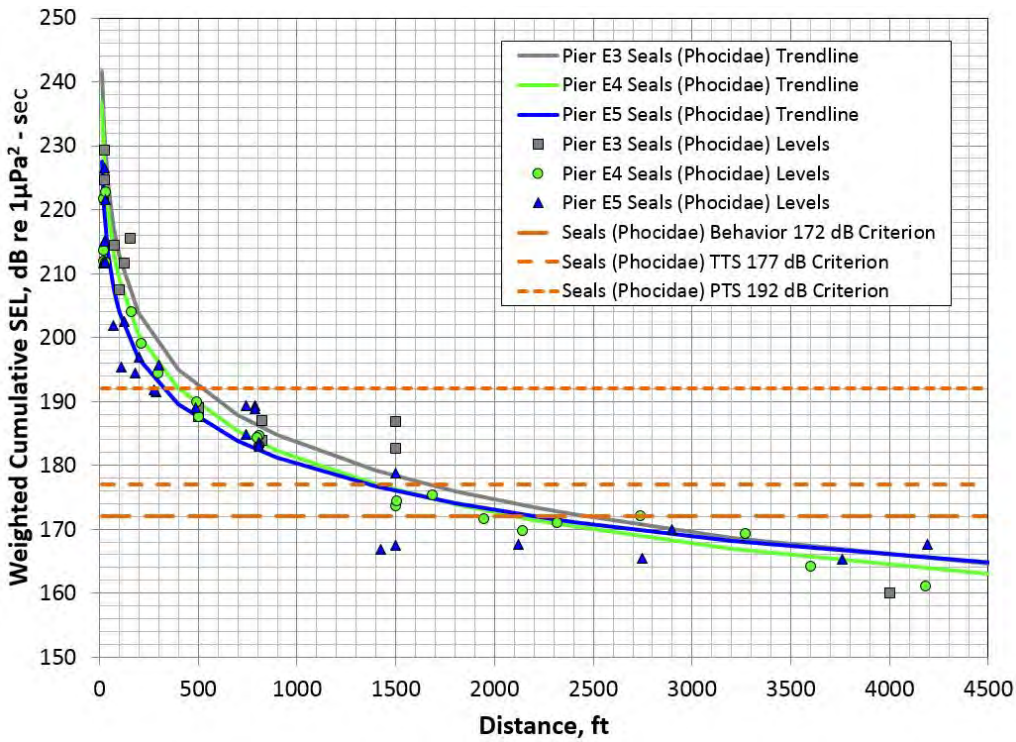

Figure 1. Marine Mammal Weighted Measured Levels for Phocidae (Harbor Seal and Elephant Seal)

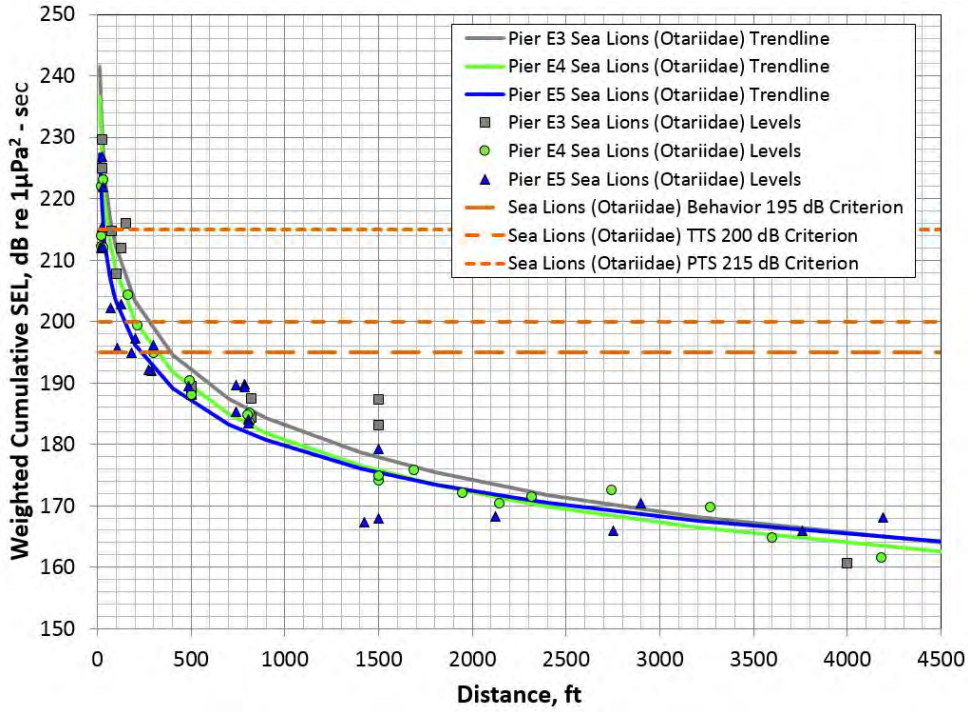

Figure 2. Marine Mammal Weighted Measured Levels for Otariidae (Sea Lion and Northern Fur Seal)

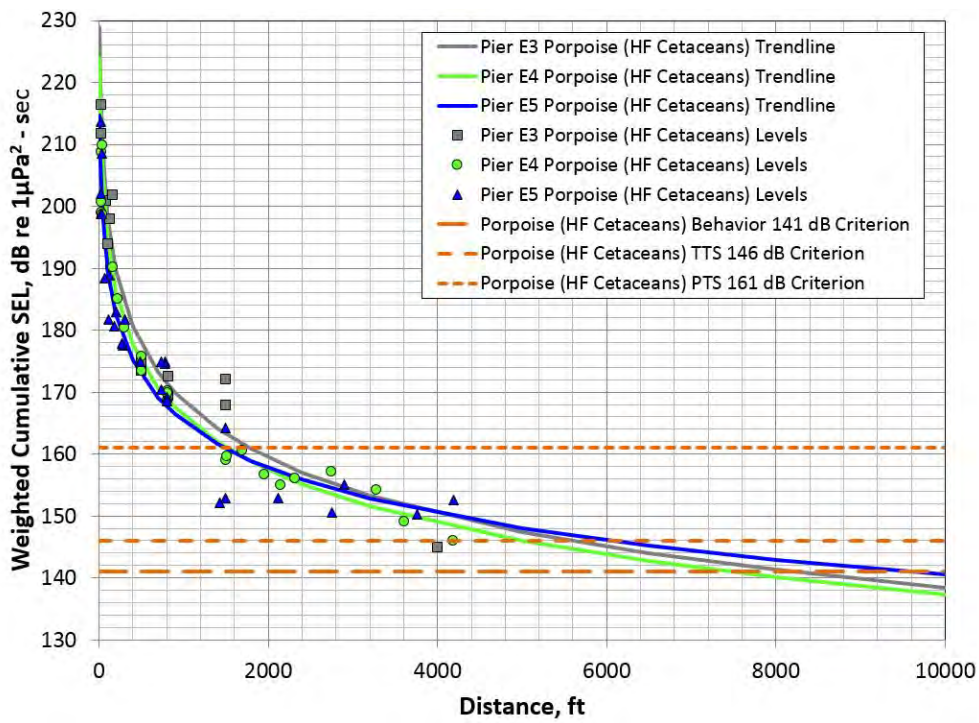

Figure 3. Marine Mammal Weighted Measured Levels for High Frequency Cetaceans (Porpoise)

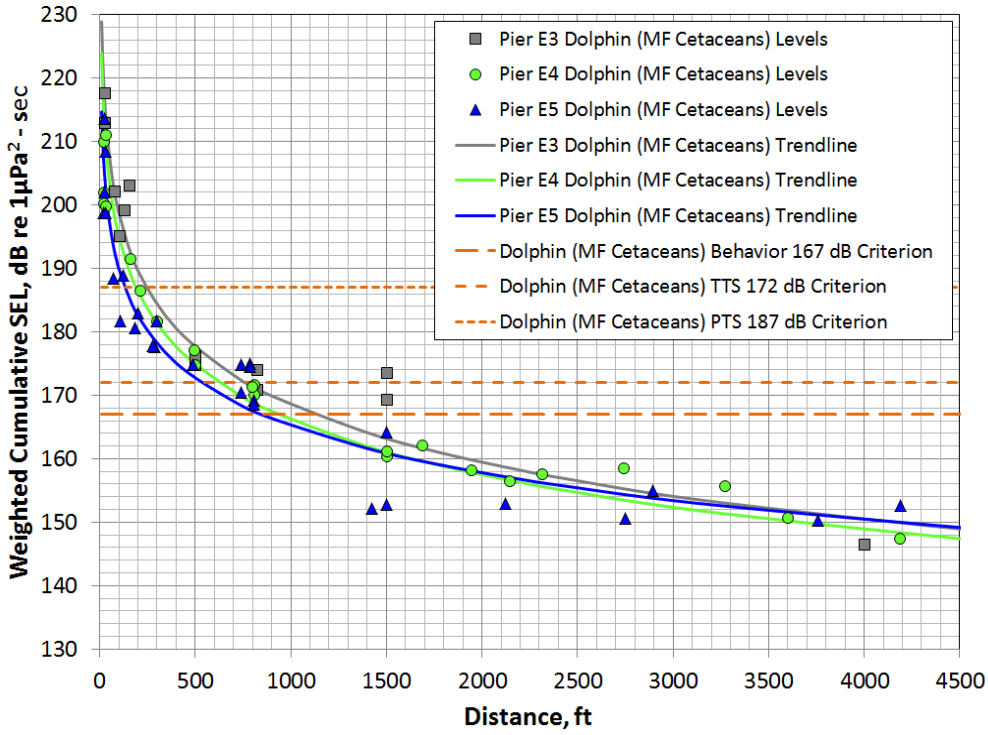

Figure 4. Marine Mammal Weighted Measured Levels for Mid Frequency Cetaceans (Dolphin)

For all marine mammal species, the same criterion level for gastrointestinal (GI) tract injury applies. The peak pressure levels measured during each implosion, which are shown in Figure 5, are compared to the GI criterion. During each pier implosion, the measured peaks were below the criteria for all measurement locations outside the Blast Attenuation System (BAS). The thresholds for lung injury and mortality are a function of the mass of the mammal, decreasing with increased mass. The thresholds for the most susceptible, smallest species, northern fur seals, are shown in Figure 6.

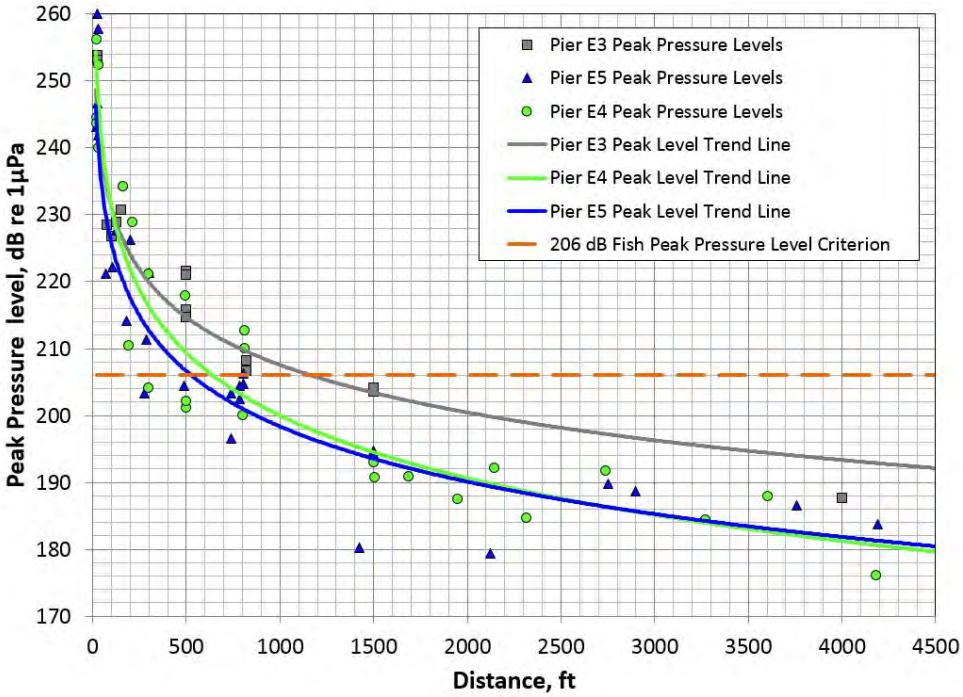

Figure 5. Peak Level Trend Lines for Piers E3, E4, and E5

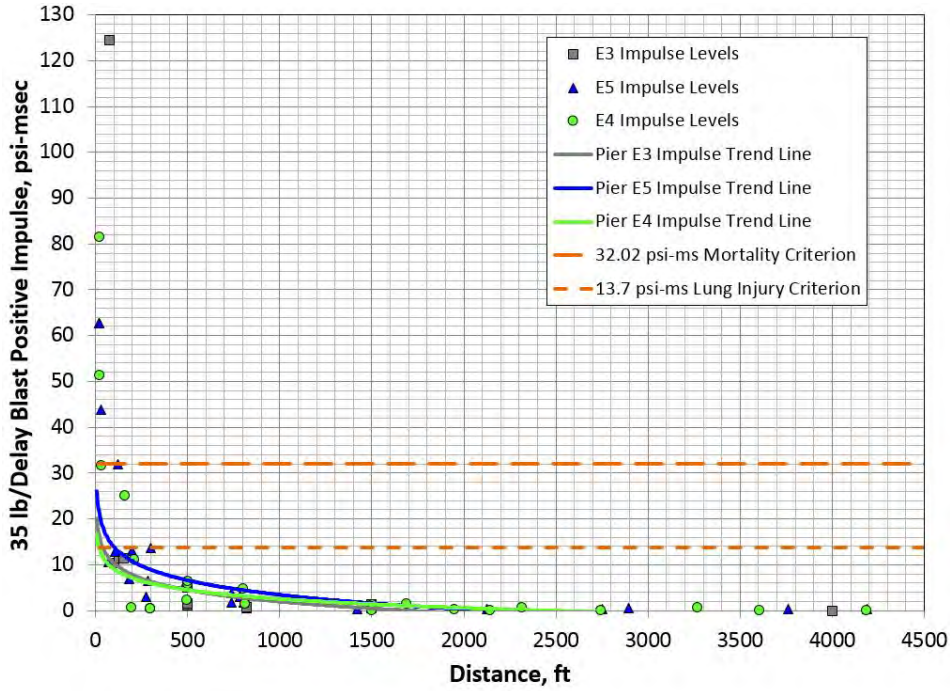

Figure 6. Summary of Impulse Results Compared to the Marine Mammal Criteria for Lung Injury and Mortality Damage

Table 3 shows the distances to all marine mammal thresholds from Piers E3, E4, and E5 based on the measurements for the respective implosion events. Because the distance to the cSEL threshold was always greater than to the L_{peak} threshold for behavior, TTS and PTS, only the distances to cSEL criteria are shown in Table 3.

Hydroacoustic monitoring results were also used to verify distances to marine mammal exclusion and monitoring zones implemented during the implosions of Piers E4 and E5. As previously discussed, measured distances to marine mammal threshold criteria from the implosion of Pier E3 were used to conservatively estimate the distances to these threshold criteria for the implosions of Piers E4 and E5.

Measured distances to all marine mammal threshold criteria from the implosions of Piers E4 and E5 are presented in Table 3. The measured distances to Level A PTS and Level B TTS and behavioral threshold criteria from the implosions of Piers E4 and E5 were smaller than those measured during the implosion of Pier E3 with the exception of the distances for harbor porpoise thresholds during Pier E5, which were slightly larger. Figures 7 and 8 show the measured distances to the phocids (harbor seal and elephant seal) Level A PTS and Level B TTS and behavioral thresholds from the implosions of Piers E5 and E4 relative to the implemented pinniped and dolphin exclusion and monitoring zones. Figures 9 and 10 show the measured distances to the high-frequency cetacean (harbor porpoise) Level A PTS and Level B TTS and behavioral thresholds from the implosions relative to the implemented harbor porpoise exclusion and monitoring zones.

Table 3. Summary of Measured Distances to the Marine Mammal Criteria

Pacific Harbor Seal and Elephant Seal (Phocidae)				
		Measured Distance to Thresholds (feet)		
Criteria	**Threshold**	**Pier E3**	**Pier E4**	**Pier E5**
Behavior	172 dB cSEL	2,460	2,110	2,197
TTS	177 dB cSEL	1,658	1,395	1,352
PTS	192 dB cSEL	507	403	315
GI Tract	237 dB Peak	< 100	< 100	< 100
Lung Injury	13.7 psi-ms	< 100	< 100	106
Mortality	32.02 psi-ms	< 100	< 100	< 100
California Sea Lion and Northern Fur Seal (Otariidae)				
		Measured Distance to Thresholds (feet)		
Criteria	**Threshold**	**Pier E3**	**Pier E4**	**Pier E5**
Behavior	195 dB cSEL	387	304	225
TTS	200 dB cSEL	261	202	139
PTS	215 dB cSEL	80	59	33
GI Tract	237 dB Peak	< 100	< 100	< 100
Lung Injury	13.7 psi-ms	< 100	< 100	106
Mortality	32.02 psi-ms	< 100	< 100	< 100
Porpoise (High Frequency Cetaceans)				
		Measured Distance to Thresholds (feet)		
Criteria	**Threshold**	**Pier E3**	**Pier E4**	**Pier E5**
Behavior	141 dB cSEL	8,171	7,446	9,564
TTS	146 dB cSEL	5,580	4,998	6,004
PTS	161 dB cSEL	1,777	1,511	1,486
GI Tract	237 dB Peak	< 100	< 100	< 100
Lung Injury	13.7 psi-ms	< 100	< 100	106
Mortality	32.02 psi-ms	< 100	< 100	< 100
Dolphin (Mid Frequency Cetaceans)				
		Measured Distance to Thresholds (feet)		
Criteria	**Threshold**	**Pier E3**	**Pier E4**	**Pier E5**
Behavior	167 dB cSEL	1,128	937	850
TTS	172 dB cSEL	774	628	533
PTS	187 dB cSEL	250	533	131
GI Tract	237 dB cSEL	< 100	< 100	< 100
Lung Injury	13.7 psi-ms	< 100	< 100	106
Mortality	32.02 psi-ms	< 100	< 100	< 100

Figure 7. Pier E5 Monitored and Measured Distances to Phocids (Harbor Seal and Elephant Seal) Threshold Criteria

Figure 8. Pier E4 Monitored and Measured Distances to Phocids (Harbor Seal and Elephant Seal) Threshold Criteria

Figure 9. Pier E5 Monitored and Measured Distances to High-Frequency Cetacean (Harbor Porpoise) Threshold Criteria

Figure 10. Pier E4 Monitored and Measured Distances to High-Frequency Cetacean (Harbor Porpoise) Threshold Criteria

Appendix C. Methods for Calculating Distances to Marine Mammal Cumulative Sound Exposure Level Thresholds for Implosion of Multiple Piers

Methods for Calculating Distances to Marine Mammal Cumulative Sound Exposure Level Thresholds for Implosion of Multiple Piers

For Piers E6 through E18, the unweighted sound exposure level (SEL) values were calculated using the average trend line for the results of Piers E3, E4, and E5 as shown below in Figure 1:

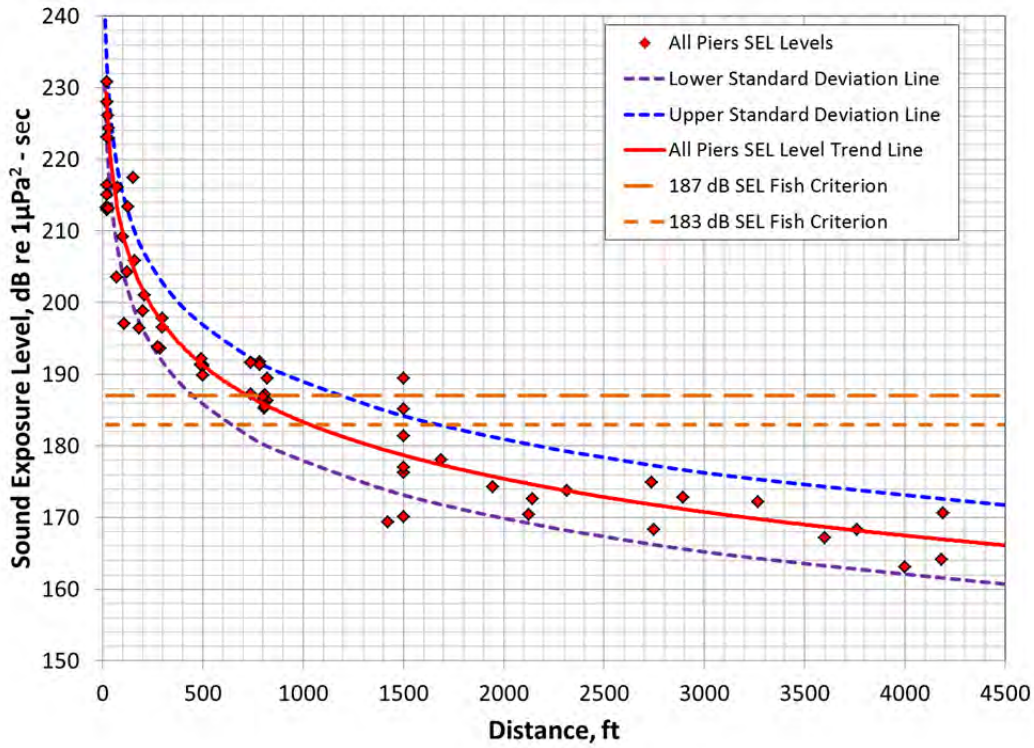

Figure 1: cSEL trend lines for the combined data set results of all three piers (E3, E4 and E5)

The magnitude of the SEL was determined based on the blast plan for each individual pier as shown below in Table 1:

Table 1: Summary of blast plans for Piers E3 through E18

Pier	Max Charge Weight (lbs)	Min Charge Weight (lbs)	Total Charges	Delay Separation Time (msec)	Total Duration (sec)
E3	35	21	588	9	5.283
E4	35	21.3	406	9	3.654
E5	35	10	288	9	2.592
E6	32	12	636	9	5.724
E7	25	15	324	9	2.916
E8	25	15	104	9	0.936
E9	25	15	282	9	2.538
E10-E16	25	15	96	9	0.864
E17-E18	25	15	102	9	0.918

The equation for the Pier E3 to E5 average unweighted trend line is given as:

$$SEL = 262.38 - 11.44Ln(R)$$

where R is the distance from the pier. The value of 11.44 is used for all of the remaining piers and defines the shape of the sound fall-off with distance. The constant value (262.38) is different for each unique pier blast plan. This term (or offset) is smaller with lower charge weights and fewer numbers of charges. For each unique blast, the specific SEL is calculated by summing the SEL calculated for each charge weight in the plan and the number of charges of that weight. For the remaining piers, the offset is lower for all of the piers except E6. Pier E6 is slightly greater than the average of Pier E3 to E5; however E6 is slightly lower than the measured Pier E3 levels. The SEL values versus distance are shown in Figure 2.

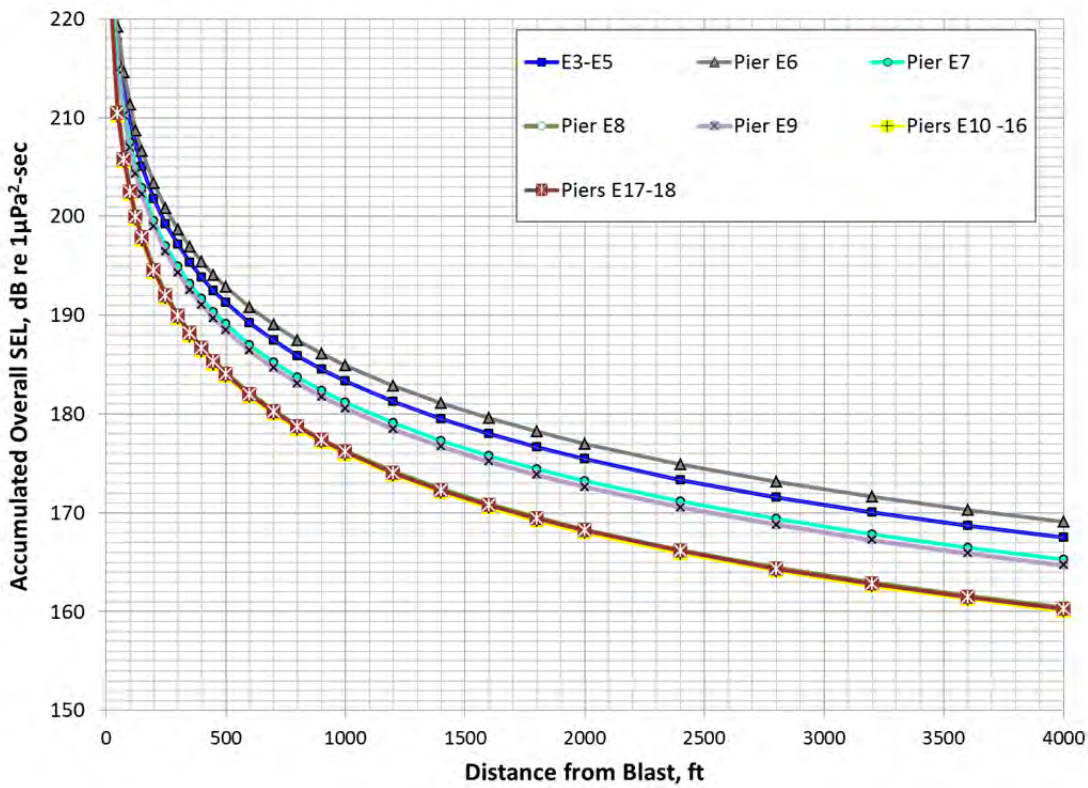

Figure 2: Estimated unweighted SEL versus distance for Piers E6 through E18 and average of the Pier E3-E5 results

For marine mammals, specific weighting is required for different species. For the implosions scheduled for 2017, the weightings and criteria levels defined by the National Marine Fisheries Service in NOAA Technical Memorandum NMFS-OPR-55, July 2016, were used. The filter shapes defined in this document were applied to underwater blast spectra at different distances to develop the filter factors shown in Figure 3 for Mid-Frequency Cetaceans (MF), High-Frequency Cetaceans (HF), Phocid Pinnipeds (P), and Otariid Pinnipeds (O) corresponding to dolphins, porpoises, seals, and sea lions, respectively. These filter factors were then applied to the unweighted SEL values shown in Figure 2 for each of the four species groups. An example of the estimated marine mammal weighted SEL is shown in Figure 4 for phocid pinnipeds along with the PTS, TTS, and Behavioral threshold levels for each of the unique piers.

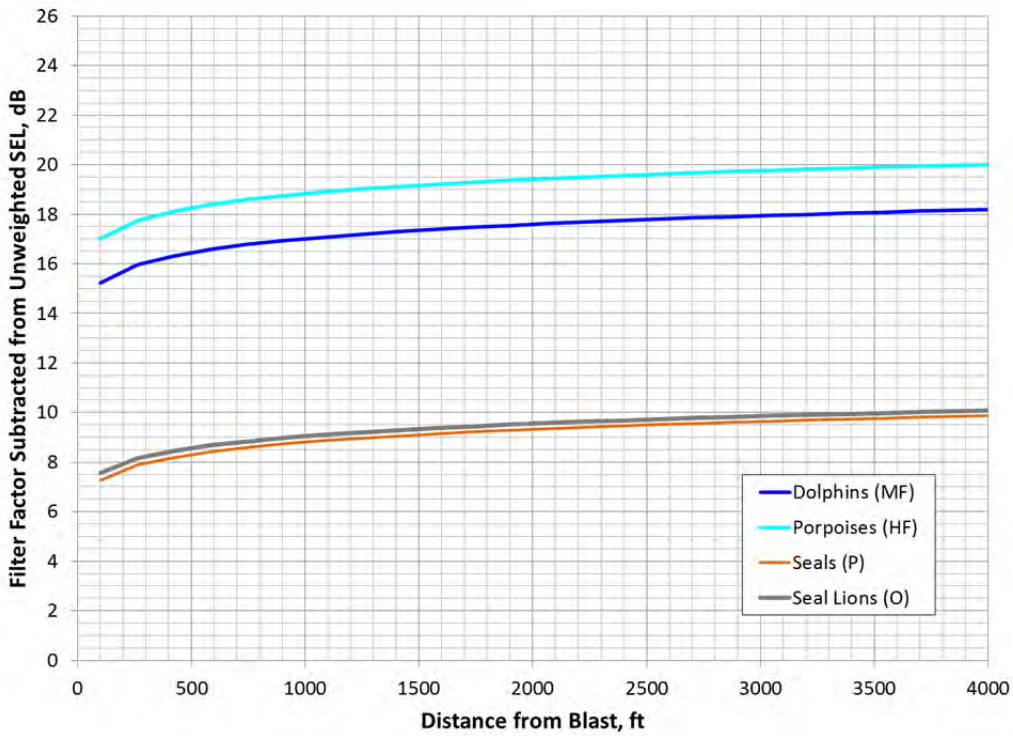

Figure 3: Marine mammal filter factors for dolphins, porpoises, seals, and sea lions to be subtracted from the unweighted SEL values (Figure 2)

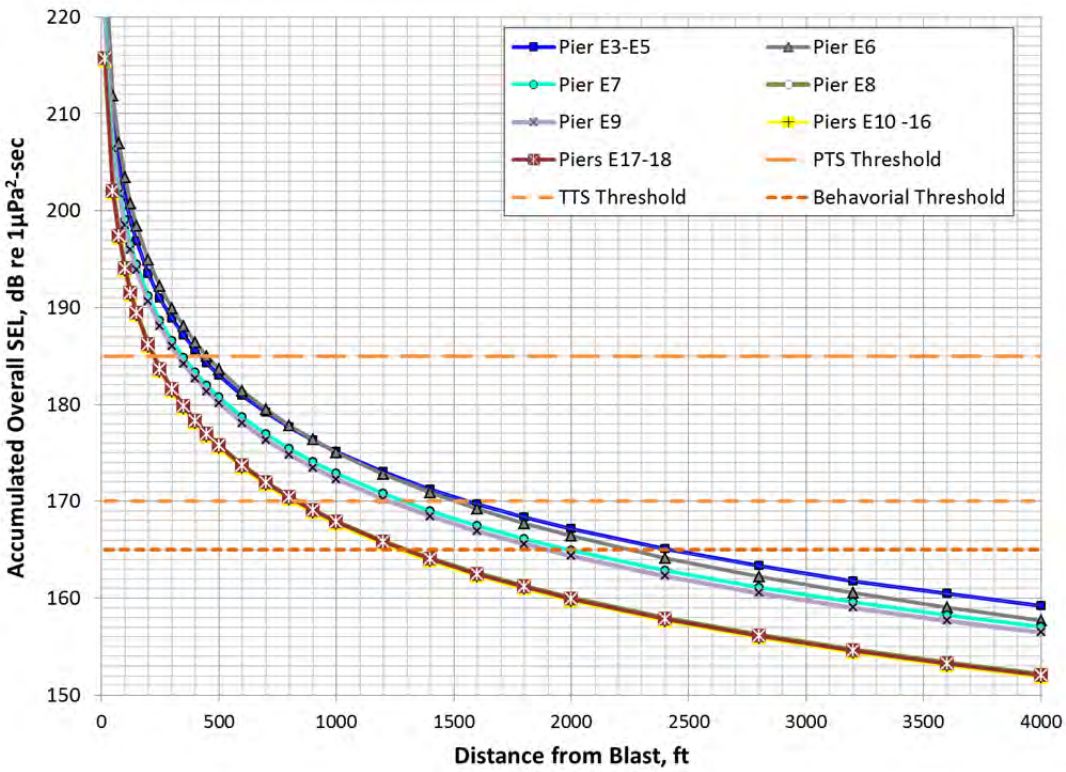

Figure 4: Estimated weighted SEL values for phocid pinnipeds (true seals) for individual piers

With the exception of Pier E6 and possibly E9, implosions of individual piers are planned to be grouped together. These groupings could include implosion of 2 to 4 piers in one event where the implosion of individual piers would be separated by 1 to 5 seconds. For the multiple pier events, the individual piers are considered in the same manner as was done for Piers E3 through E5. The dimensions of the piers are assumed to be small compared to the distances of the receivers and self-shielding and progression of the charges of the implosion event are not included. For the multiple pier events, the physical separation between the piers is taken into account. For Pier E7 and E8, this separation is 504 feet and the others are all 288 feet. For the sets of two piers, for any receiver location in the plan view, the distance to each pier is determined. The SEL value for each pier is determined using the proper SEL versus distance curve from Figure 4. The two SEL values are summed together on an acoustic energy basis and the total SEL at the point is determined. This process is then repeated at different points along lines coming out from the two piers. It should be noted that the SEL calculation is not dependent on time and it is simply the total of all energy accumulating in up to a 24-hour time period. As a result, it does not matter if the implosions occurred at the same time, separated by 1 second, 1 hour, or any amount less than 24 hours.

An example of the results of this approach is shown below in Figure 5 for the paired implosions of Pier E7 and E8 as it applies to phocid pinnipeds (true seals). In the upper right corner, a schematic of the analysis lines are shown. SEL versus distance for each of the lines is plotted color coded to the analysis

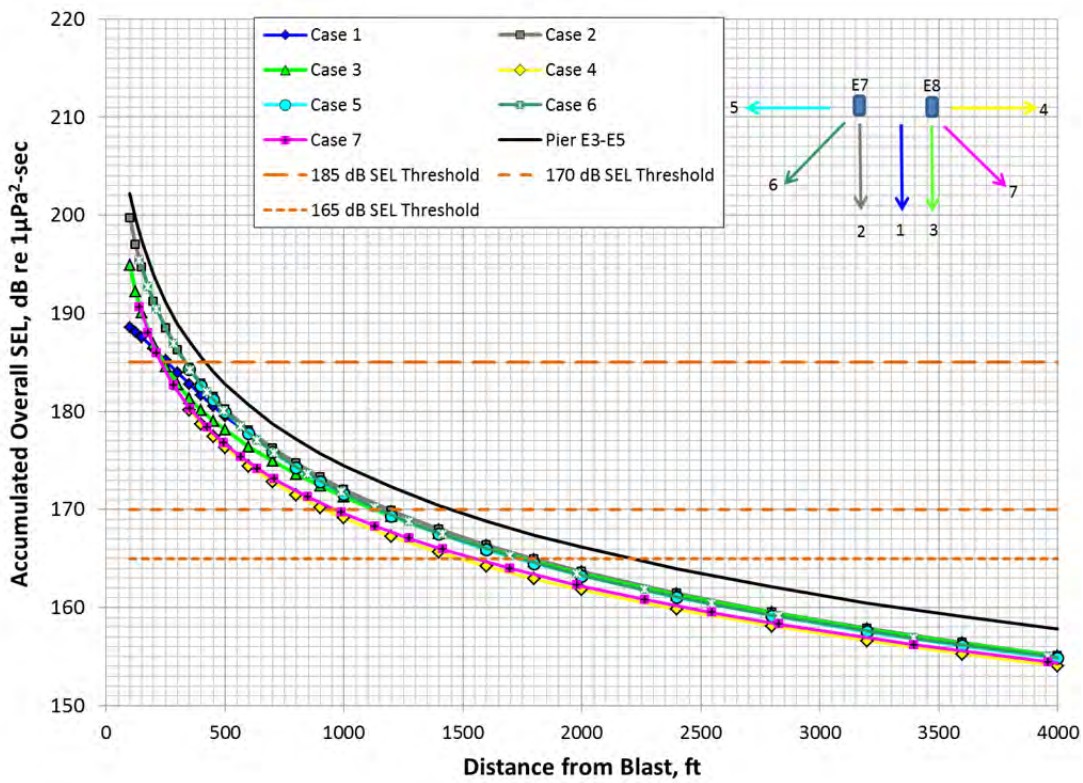

Figure 5: Estimated seal weighted SEL results for Piers E7 and E8

line. At points along the lines, the SEL for each individual pier is determined by calculating the distance to each pier from the receiver location. These are then summed together to get the total SEL as illustrated in Figure 6 for the line going diagonally from Pier E8. For the case in Figure 5, the offset for Pier E7 is about 5 decibels (dB) greater than E8 (see Figure 4). As a result, the SEL lines emanating from

Pier E8 (cases 4 and 7) are consistently lower than others that are more influenced by their proximity to E7. This difference can be up to almost 3 dB at some distances. The SEL values for the combined Pier E7 and E8 implosions are less than those of the average of Piers E3, E4 and E5 also indicated in Figure 5.

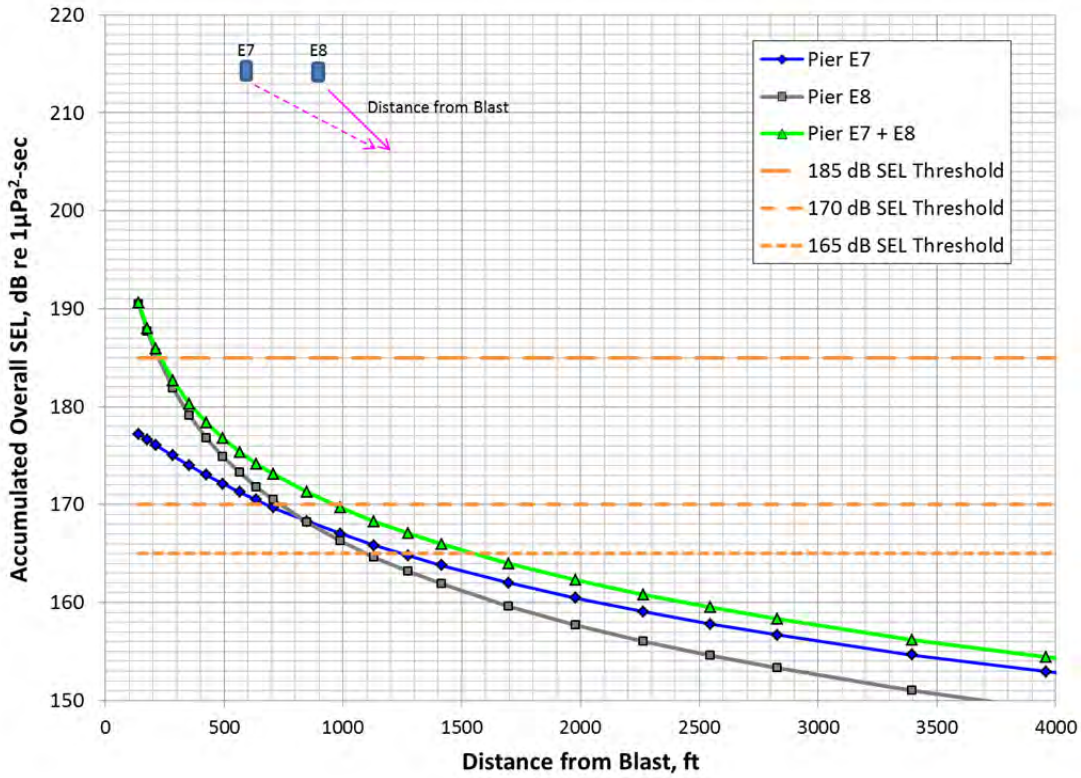

Figure 6: Estimated phocid pinniped weighted SEL in the direction indicated results for Piers E7 and E8 individually and combined

Another multi-pier case is that of Piers E16, 17, and 18. The SEL of Pier E16 is slightly (0.3 dB) less than the SELs of E17 and E18 (Table 2). The estimates for the three piers individually and combined for the direction out from Pier E16 are shown in Figure 7. At distances close to E16, the SEL from that pier is greater than the other two by about 11 dB and 18 dB and Pier E16 essentially defines the total SEL. Going away from the Pier E16, the difference in the relative contributions of the piers diminishes to just 1 or 2 dB at 2500 feet and beyond. The SEL values for all directions are shown in Figure 8. For this case, the higher levels are to the side of the line of the 3 piers, cases 1, 2, and 3. Between 300 and 1300 feet, these cases are about 2 dB higher than cases 4 through 7.

The cases where four piers may be imploded as one event were calculated in the same manner except the contribution from all four piers define the total. The case for the combination of E15, E16, E17, and E18 is shown in Figure 9. These calculations were replicated for all of the pier groupings and for the other three species using their specific weighting and criteria.

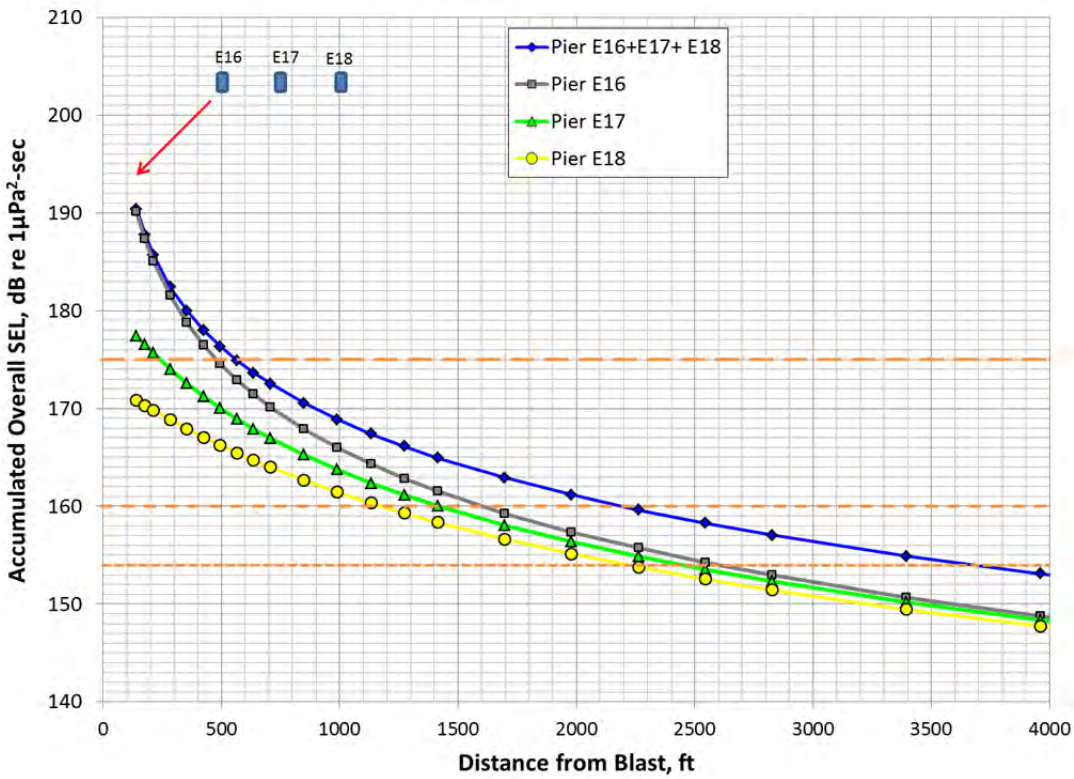

Figure 7: Estimated phocid pinniped (true seal) weighted SEL values for Piers E16, E17 and E18 individually and combined along the line as indicated (Case 6)

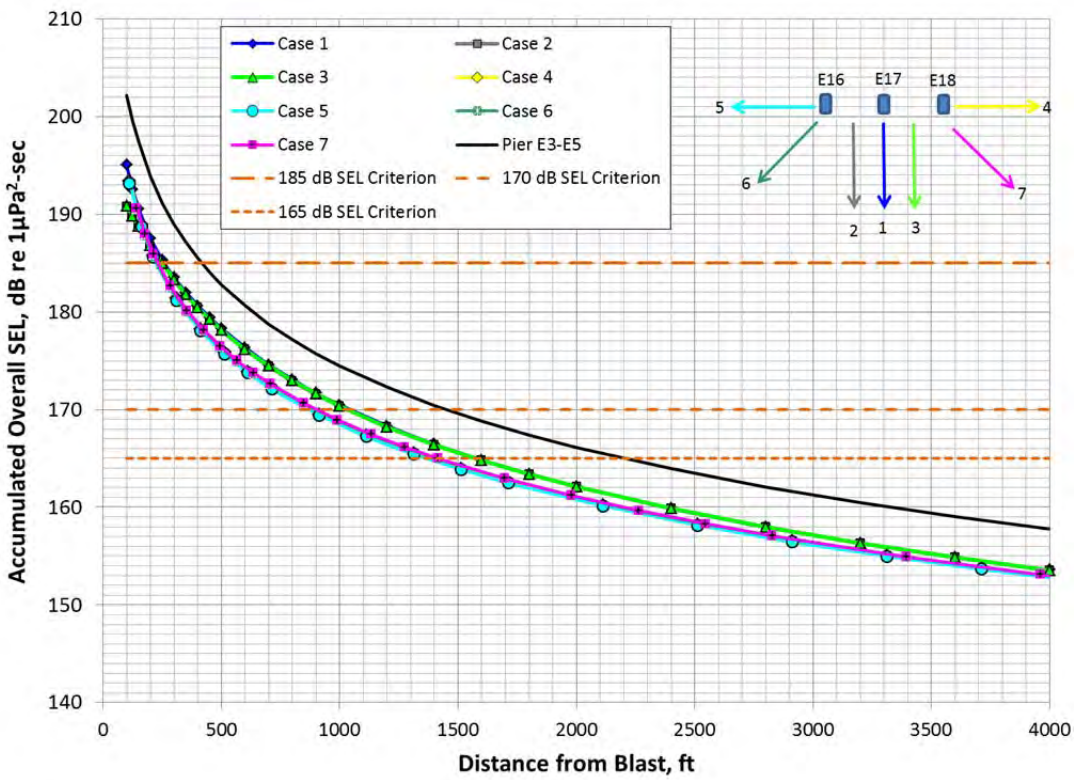

Figure 8: Estimated phocid pinniped (true seal) weighted SEL results for Piers E16, E17 and E18

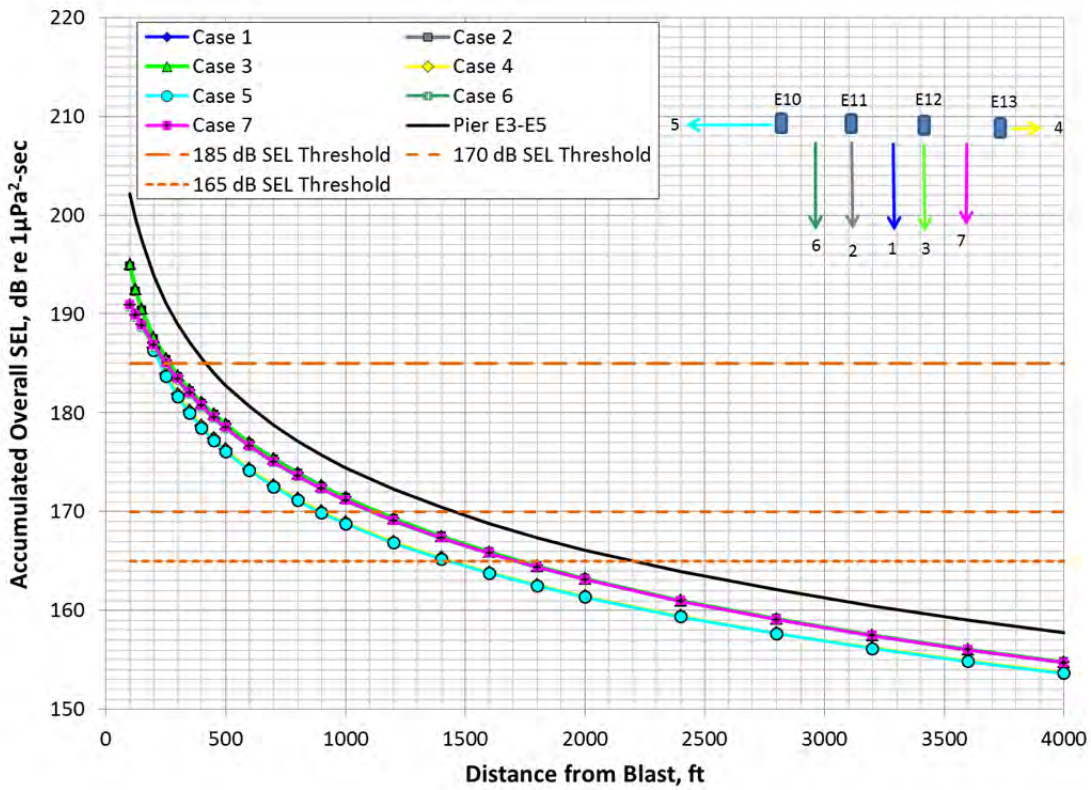

Figure 9: Estimated phocid pinniped (true seal) weighted SEL values for Piers E15, E16, E17 and E18

Appendix D. Marine Mammal Exposure Calculations

Table 1. Pier Implosion Pinniped Exposure Estimate Calculations

Pier Implosion Scenario	**Distance** (feet)	**Acreage**	**Description**	**Area** (km^2)	**Harbor Seal** (Density x Area)	**Sea Lion** (Density x Area)	**Elephant Seal** (Density x Area)
Two 288' Span Piers	367	17.51051702	367 foot Pinniped and Dolphin PTS Exclusion Zone	0.0709	0.2908	0.0064	0.0021
Three 288' Span Piers	367	22.89160118	367 foot Pinniped and Dolphin PTS Exclusion Zone	0.0927	0.3801	0.0083	0.0028
Four 288' Span Piers	367	28.54704852	367 foot Pinniped and Dolphin PTS Exclusion Zone	0.1156	0.4740	0.0104	0.0035
Two 504' Span Piers	400	25.82477198	400 foot Pinniped and Dolphin PTS Exclusion Zone	0.1046	0.4288	0.0094	0.0031
Pier E6	532	25.39152251	532 foot Pinniped and Dolphin PTS Exclusion Zone	0.1028	0.4216	0.0093	0.0031
Two 288' Span Piers	1080	105.65459	1,080 foot Pinniped and Dolphin Level B TTS Zone	0.4279	1.7544	0.0385	0.0128
Three 288' Span Piers	1254	155.1964068	1,254 foot Pinniped and Dolphin Level B TTS Zone	0.6285	2.5770	0.0566	0.0189
Four 288' Span Piers	1362	197.6434141	1,362 foot Pinniped and Dolphin Level B TTS Zone	0.8005	3.2819	0.0720	0.0240
Two 504' Span Piers	1423	192.5675065	1,423 foot Pinniped and Dolphin Level B TTS Zone	0.7799	3.1976	0.0702	0.0234
Pier E6	1781	244.8517385	1,781 foot Pinniped and Dolphin Level B TTS Zone	0.9916	4.0658	0.0892	0.0297
Two 288' Span Piers	1631	223.966573	1,631 foot Pinniped and Dolphin Level B Behavioral Response Zone	0.9071	3.7190	0.0816	0.0272
Three 288' Span Piers	1896	321.703444	1,896 foot Pinniped and Dolphin Level B Behavioral Response Zone	1.3029	5.3419	0.1173	0.0391
Four 288' Span Piers	2076	396.9540528	2,076 foot Pinniped and Dolphin Level B Behavioral Response Zone	1.6077	6.5914	0.1447	0.0482
Two 504' Span Piers	2148	402.0739132	2,148 foot Pinniped and Dolphin Level B Behavioral Response Zone	1.6284	6.6764	0.1466	0.0489
Pier E6	2644	527.8473522	2,664 foot Pinniped and Dolphin Level B Behavioral Response Zone	2.1378	8.7649	0.1924	0.0641

Species	**Density** (animals/km^2)
Harbor Seal	4.1
Sea Lion	0.09
Elephant Seal	0.03

Note: Distances and areas are based on calculated distances to the thresholds for onset of behavioral response, TTS and PTS to phocide pinnipeds and the corresponding exclusion and monitoring zones that will be established for all pinnipeds and dolphins. These distances and areas are conservative for otariid pinnipeds and bottlenose dolphin which have smaller zones for behavioral response, TTS and PTS.

Table 2. Pinniped Exposure Estimates for Pier Implosion Scenarios

Pier Implosion Scenario	Harbor Seal Behavioral Exposures	Harbor Seal TTS Exposures	Harbor Seal PTS Exposures	Sea Lion Behavioral Exposures	Sea Lion TTS Exposures	Sea Lion PTS Exposures	Elephant Seal Behavioral Exposures	Elephant Seal TTS Exposures	Elephant Seal PTS Exposures
Pier E6	5.1208	3.6441	0.4216	0.1032	0.0800	0.0093	0.0344	0.0267	0.0031
Two 504' Span Piers	3.9077	2.7688	0.4288	0.0764	0.0608	0.0094	0.0255	0.0203	0.0031
Two 288' Span Piers	2.2553	1.4636	0.2908	0.0431	0.0321	0.0064	0.0144	0.0107	0.0021
Three 288' Span Piers	3.1450	2.1969	0.3801	0.0607	0.0482	0.0083	0.0202	0.0161	0.0028
Four 288' Span Piers	3.7836	2.8078	0.4740	0.0726	0.0616	0.0104	0.0242	0.0205	0.0035

Note: Because a marine mammal can be taken only once in a 24-hour period, the estimated exposures for the PTS zone were subtracted from the TTS zone exposures, and the TTS zone exposures were subtracted from the behavioral response zone exposures; therefore an animal was not counted as being exposed multiple times.

Table 3. Pier Implosion Harbor Porpoise Exposure Estimate Calculations

Pier Implosion Scenario	Distance (feet)	Acreage	Description	Area (km^2)	Harbor Porpoise (Density x Area)
Two 288' Span Piers	1877	290.9186399	1,877 foot Harbor Porpoise PTS Exclusion Zone	1.1773	0.0247
Three 288' Span Piers	2066	375.7268278	2,066 foot Harbor Porpoise PTS Exclusion Zone	1.5206	0.0319
Four 288' Span Piers	2300	473.8281761	2,300 foot Harbor Porpoise PTS Exclusion Zone	1.9176	0.0403
Two 504' Span Piers	2359	477.2812963	2,359 foot Harbor Porpoise PTS Exclusion Zone	1.9316	0.0406
Pier E6	2951	653.9898385	2,951 foot Harbor Porpoise PTS Exclusion Zone	2.6467	0.0556
Two 288' Span Piers	6168	2523.304642	6,168 foot Harbor Porpoise Level B TTS Zone	10.2118	0.2144
Three 288' Span Piers	7080	3103.298173	7,080 foot Harbor Porpoise Level B TTS Zone	12.5590	0.2637
Four 288' Span Piers	7908	3620.76237	7,908 foot Harbor Porpoise Level B TTS Zone	14.6532	0.3077
Two 504' Span Piers	8160	3749.617234	8,160 foot Harbor Porpoise Level B TTS Zone	15.1747	0.3187
Pier E6	10030	4874.605899	10,030 foot Harbor Porpoise Level B TTS Zone	19.7275	0.4143
Two 288' Span Piers	9240	4492.654876	9,240 foot Harbor Porpoise Level B Behavioral Response Zone	18.1818	0.3818
Three 288' Span Piers	11284	6026.681111	11,284 foot Harbor Porpoise Level B Behavioral Response Zone	24.3900	0.5122
Four 288' Span Piers	11922	6507.73832	11,922 foot Harbor Porpoise Level B Behavioral Response Zone	26.3368	0.5531
Two 504' Span Piers	12360	6871.38862	12,360 foot Harbor Porpoise Level B Behavioral Response Zone	27.8085	0.5840
Pier E6	15080	9054.814587	15,080 foot Harbor Porpoise Level B Behavioral Response Zone	36.6448	0.7695

Species	Density (animals/km^2)
Harbor Porpoise	0.021

Note: Distances and areas are based on calculated distances to the thresholds for onset of behavioral response, TTS and PTS to high-frequency cetaceans (harbor porpoise) and the corresponding exclusion and monitoring zones that will be established for harbor porpoise.

Table 4. Harbor Porpoise Exposure Estimates for Pier Implosion Scenarios

Pier Implosion Scenario	Harbor Porpoise Behavioral Exposures	Harbor Porpoise TTS Exposures	Harbor Porpoise PTS Exposures
Pier E6	0.4108	0.3587	0.0556
Two 504' Span Piers	0.3059	0.2781	0.0406
Two 288' Span Piers	0.1921	0.1897	0.0247
Three 288' Span Piers	0.2804	0.2318	0.0319
Four 288' Span Piers	0.2856	0.2674	0.0403

Note: Because a marine mammal can be taken only once in a 24-hour period, the estimated exposures for the PTS zone were subtracted from the TTS zone exposures, and the TTS zone exposures were subtracted from the behavioral response zone exposures; therefore an animal was not counted as being exposed multiple times.

Appendix E. Alternatives Analysis

GANDA

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To: Mr. Stefan Galvez (SFOBB Environmental Compliance Manager)

From: Alex Pries

Date: January 30, 2015

RE: **SFOBB East Span Seismic Safety Project (SFOBB Project) Marine Mammal Impacts from Pier E3 Cofferdam Installation**

Removal of the marine foundations of the original east span of the San Francisco-Oakland Bay Bridge (SFOBB) is required as part of regulatory requirements for the SFOBB East Span Seismic Safety Project (SFOBB Project). Due to the schedule, cost, and environmental benefits when compared to mechanical demolition, the California Department of Transportation (Department) has proposed controlled implosion as the preferred alternative methodology of removal. Potential impacts to biological resources by the proposed demolition were previously presented in a biological evaluation. Up to a total of 22 marine foundations of the original east span may be removed to meet regulatory requirements. Three of these piers, E3 – E5, are deep-water caissons that require more complex methods for their removal.

The purpose of this memorandum is to present the evaluation of methodology and potential impacts to marine mammals from removal of Pier E3, the deepest marine foundation of the SFOBB, by means of installing a cofferdam around the structure prior to mechanical dismantling via ram hoe or saw cutting. This method is evaluated as an alternative to the preferred method of removing Pier E3 through controlled implosion.

Description of the Alternative to the Proposed Action:

For the purpose of analysis, the Department has prepared a conceptual plan for dismantling the concrete caisson supporting Pier E3, which is located approximately 1,535 feet (468 meters) east of Yerba Buena Island (YBI) in San Francisco Bay. Prior to demolition of this marine foundation, the Department would complete the removal of the above-water bridge superstructure, including the original cantilever span, truss, truss span, and supporting tower on Pier E3. Removal of the marine foundation via mechanical dismantling methods would require installation of a cofferdam, dewatering activities, and use of conventional equipment (i.e., ram

hoe or wire saw) to break the pier into smaller pieces for disposal.

Impacts to marine mammals from the proposed action would largely come from the marine propagation of impulse sound associated with the impact driving of piling to support and build the cofferdam. Exposure to impulse sound can result in short-term hearing loss (i.e., temporary threshold shift [TTS]), permanent hearing loss (i.e., permanent threshold shift [PTS]), and a variety of physical injuries up to mortality. Once installed, the area inside the cofferdam would be dewatered and the sound associated with mechanical dismantling is expected to be negligible in the marine environment. Thus, any impacts to marine mammals or their habitat from dismantling activities would be minimal. Impacts to marine mammals and their habitat from the sound associated with pile driving during cofferdam installation will be the key focus of this analysis. The use of vibratory methods to install piles is preferred and believed to have lesser impacts to marine mammals than impact pile driving methods. Vibratory installation of piles works well in soft sediments, but can be difficult if rocks, debris, or harder sediment layers impede installation of the pile. Additionally, for the Pier E3 cofferdam, obtaining a secure final elevation for the larger piles will be particularly critical to ensure the cofferdam's structural stability for holding back Bay waters and to create a safe working environment. As a result, Department engineers concluded for this analysis that the large diameter piles (e.g., 54" bulkhead pile and king pile) would require impact driving, and not vibratory methods, to obtain final, secure pile depth.

Installation of the Pier E3 cofferdam is anticipated to require the following pile array:

- Thirty six (36) 54" diameter 150 foot long bulkhead pipe piles [to prevent vessel impacts from breaching the cofferdam];
- One-hundred seventy (170) 145 foot long king or H-piles [HZM 1180M-D];
- Eighteen (18) 24" diameter 85 foot long support pipe piles;
- One-hundred seventy (170) 145 foot long sheet piles [AZ 26-700]

For the purpose of this analysis, installation of the above materials to a final elevation of approximately 57 feet below mudline (-114 feet 1929 NGVD) are as follows:

- All 36 bulkhead piles (54" diameter) would be impact driven with an attenuation system (i.e., bubble curtain) installed around the pile. An estimated 1,425 total strikes per pile would be required to reach final elevation. The anticipated impact hammer would be a Delmag D-100 with hammer energies between 214-360 kilojoules (kJ) per strike.
- All 170 king (H) piles would be impact driven with an attenuation system installed around the pile. An estimated 4,800 total strikes per pile would be required to reach final elevation. The anticipated hammer would be a Delmag D-100 with hammer energies between 214-360 kilojoules (kJ) per strike.
- All 18 support pipe piles (24" diameter) would be installed using a vibratory hammer, and then pile proofed to confirm elevation and stability. Pile proofing would involve a maximum of 20 strikes per pile using unattenuated impact driving. However, the use of an attenuation system is not practical given the amount of time required to set up

the system for a small number of strikes. The anticipated hammer for pile proofing of the support piles would be a Delmag 80 with hammer energies between 171-288 kJ per strike.

- All sheet piles (170 total) would be installed using a vibratory hammer, and one half (85 total) also would be proofed to confirm elevation and stability. As with the support piles, sheet pile proofing would involve a maximum of 20 strikes per sheet pile using unattenuated impact driving. The anticipated hammer for sheet pile proofing and unattenuated impact driving of sheet piles would be a Delmag D-46 with hammer energies between 71-166 kJ per strike.

Existing Guidance on SFOBB Pile-Driving Activities:

On December 18, 2013, the National Marine Fisheries Service (NMFS) issued an Incidental Harassment Authorization (IHA) to the Department for impacts to marine mammals from pile-driving activities associated with the SFOBB Project. The IHA distinguishes harassment into Levels A and B. Level A Harassment includes PTS, physical injury, or mortality. Level B Harassment is subdivided into Level B Behavioral Harassment, which may elicit a behavioral response from a marine mammal and Level B TTS Harassment. This document provided NMFS' guidance on the allowed amount of incidental exposure to Level B Behavioral Harassment for marine mammals from the SFOBB Project (Table 1). In addition, the IHA identifies temporary exclusion zones and Level B Behavioral harassment zones associated with Project pile-driving activities. Temporary exclusion zones are areas where individuals might be subject to Level B TTS Harassment and Level A Harassment during pile-driving activities. No pile driving is permitted to begin if a marine mammal is present in the temporary exclusion zone before activities begin. Pile-driving activities may occur when individual marine mammals are present in the Level B Behavioral Harassment zone. These zones are presented in Table 2, and include:

- Exclusion zones [Level B Harassment (TTS) or Level A Harassment (PTS or greater harm)] where sound pressure levels exceed 180 dB RMS (cetaceans) and 190 dB RMS (pinnipeds);
- A Level B Behavioral Harassment zone for impact pile driving noise level of equal to or greater than 160 dB RMS, and for vibratory pile driving noise level equal to or greater than 120 dB RMS.

Prior hydroacoustic monitoring of the area around the SFOBB has indicated that ambient noise levels often are greater than 120 dB, the level cited above for the onset of behavioral changes in marine mammals from vibratory pile driving. This portion of the Bay is a busy area with marine vessels transiting through the area on their way to the Port of Oakland. Because of this, it can be difficult to measure the distance to 120 dB RMS in the field. As a result, NMFS has established a distance of 2,000 meters from pile driving as the exposure area for Level B Behavioral Harassment from vibratory pile driving. This distance is assumed as the point where noise levels reach their baseline, or ambient, Bay conditions.

Table 1. Species and number of marine mammals allowed exposure (or 'take') to Level B Behavioral Harassment under the 2014 IHA for pile-driving activities.

Species	Take Allowed
Pacific harbor seal	50
California sea lion	10
Harbor porpoise	10
Gray whale	5

Table 2. Temporary Exclusion Zones [Level B (TTS) and Level A (PTS or greater harm) Harassment] and Level B Behavioral Harassment Zones for SFOBB pile-driving activities from 2014 IHA.

		Level B Behavioral Harassment Zone		Temporary Exclusion Zone [Level B (TTS) and Level A (PTS or greater harm) Harassment]	
Pile Driving Activity	**Pile Size**	**Distance to 120 dB RMS (m)[1]**	**Distance to 160 dB RMS (m)[2]**	**Distance to 180 dB RMS (m)[2] (cetaceans)**	**Distance to 190 dB RMS (m)[2] (pinnipeds)**
Vibratory Driving	24"	2,000	NA	NA	NA
	36"	2,000	NA	NA	NA
	Sheet pile	2,000	NA	NA	NA
Attenuated Impact Driving	24"	NA	1,000	235	95
	36"	NA	1,000	235	95
Unattenuated Pile Proofing	24"	NA	1,000	235	95
	36"	NA	1,000	235	95
Unattenuated Impact Driving	H-Pile	NA	1,000	235	95

[1] Threshold only applies to vibratory pile driving.
[2] Threshold only applies to impact pile driving.

Under the 2014 IHA, marine mammal observers are required to monitor areas around SFOBB prior to the initiation of pile driving activities. If individual marine mammals are within the identified temporary exclusion zones (180 dB or 190 dB RMS), pile driving activities will be delayed until the individual leaves the area. If an individual enters the 180 or 190 dB RMS exclusion zone after the commencement of pile driving, the Department is required to notify NMFS within 24 hours.

Hydroacoustic Analysis of Pier E3 Cofferdam (under current regulations)

A calculation of the distance to temporary exclusion (Level B [TTS] or Level A Harassment) zones and Level B Behavioral Harassment zones for installation of the Pier E3 cofferdam is presented below based on hydroacoustic analyses completed by Illingworth & Rodkin. Data

from the *Compendium of Pile Driving Sound Data* were used to establish the baseline source levels. The average RMS levels recorded for several projects were used to predict potential sound levels for the Pier E3 cofferdam installation. For installation of the 24" support pipe piles, data from the Amorco Wharf repair in San Francisco Bay, Tongue Point dock repair on the Columbia River in Oregon, Rodeo Dock repair in San Francisco Bay, Schuyler Heim Bridge replacement project in the Port of Long Beach, the Northern Rail project in Alaska, and the retrofit of the Richmond-San Rafael Bridge in San Francisco Bay were considered. For the 54" bulkhead pipe piles, data from the driving of 48" piles for the SFOBB Project were used exclusively. Distances were calculated for one impacted pile per day un-attenuated and attenuated with the assumption of 25 strikes per foot (1,425 total strikes per pile) for each pile type during impact driving. The maximum of 20 strikes per pile was assumed for unattenuated pile proofing of sheet piles and 24" support piles. Table 3 summarizes the distance to Temporary Exclusion and Level B Behavioral Harassment zones per pile activity for the Pier E3 cofferdam, under adherence to current SFOBB Project pile-driving regulations.

Table 3. Modeled Temporary Exclusion and Level B Behavioral Harassment Zones for the Pier E3 cofferdam.

		Level B Behavioral Harassment Zone		**Temporary Exclusion Zone (Level B [TTS] and Level A [PTS or greater harm] Harassment)**	
Pile Driving Activity	**Pile Size**	**Distance to 120 dB RMS (m)[1]**	**Distance to 160 dB RMS (m)[2]**	**Distance to 180 dB RMS (m)[2] (cetaceans)**	**Distance to 190 dB RMS (m)[2] (pinnipeds)**
Vibratory Driving	24"	2,000	--	--	--
	Sheet Pile	2,000	--	--	--
Attenuated Impact Driving	54"	--	338	23	6
	King Pile	--	225	15	4
Unattenuated Pile Proofing	24"	--	582	39	10
	Sheet Pile	--	508	34	9

[1] Threshold only applies to vibratory pile driving.
[2] Threshold only applies to impact pile driving.

SUMMARY

In summary, the total area subject to Level B Behavioral Harassment of marine mammals is much larger for the cofferdam installation scenario, largely due to the increased time required to install the piles than for the controlled implosion scenario. The cumulative area exposed to Level B (TTS) or Level A (PTS or greater harm) Harassment of marine mammals is higher for the one-day controlled implosion (109 acres) when compared at the 190 dB RMS threshold for pinnipeds (9.3 acres) during cofferdam installation. However, for cetaceans (the 180 dB RMS threshold), cumulative exposure during pile driving would be approximately one and a half times the area of the controlled implosion scenario (147 acres versus 109 acres). The actual risk of Level A Harassment exposure to individual marine mammals from either demolition method is unlikely

given the implementation of exclusion zones and monitoring. Exposure to Level B (TTS) Harassment of three harbor seals may occur from the controlled implosion. In contrast, the increased time (months to years) required to install the cofferdam, along with historical monitoring data, suggest there is a potential for equal, or greater, TTS exposure under this method. This could occur even with effective monitoring, because current regulations allow for continued pile driving if an individual enters the exclusion zone after work has commenced

The proposed installation of a Pier E3 cofferdam under adherence to current SFOBB Project IHA pile-driving regulations for marine mammals is achievable. The modeled distances for impact and vibratory driving of the piles required for the cofferdam are well within the accepted distances as defined in the Project's current IHA. However, the time and duration required to install all piles for the cofferdam also would increase the potential for individual exposure. With a total of 394 piles proposed for the Pier E3 cofferdam and more restrictive regulations on daily sound exposure from pile driving under the 2012 NMFS Biological Opinion (BO) for marine fish, pile driving for the cofferdam likely would occur for months to years. This increased duration for pile driving may increase the potential risk for individual exposure to harassment.

While marine mammal monitoring during pile driving for the E3 cofferdam may result in no exposures greater than behavioral harassment, the installation of piles for the cofferdam likely will result in a similar outcome as the controlled implosion (e.g., some TTS exposure). This is because the increased duration of pile driving actions (months/years) when compared to the controlled implosion (seconds) may increase the probability of exposing an individual to TTS. Since 2001, a total of 19 harbor seals and 3 California sea lions have been observed, during 210 days of monitoring for the SFOBB Project, entering the Level B (TTS) Harassment Zone after pile driving activities began. These numbers suggest there is about a 10% chance of encountering a harbor seal daily inside the Level B (TTS) Harassment Zone while pile driving. For California sea lions, this chance is about 1.5%. Using these values and an assumption of pile-driving for the cofferdam requiring 394 days (i.e, one pile per day), potential TTS exposure could occur to 39 harbor seals and six California sea lions.

In contrast, the current blast plan would remove Pier E3 down to mudline and the detonation sequence would last for approximately **5 to 6** seconds. On-site work in advance of the implosion would likely take months, but is anticipated to result in negligible disturbance to the marine environment when compared to the hydroacoustic impacts associated with pile driving. In late 2013, NMFS developed new regulatory thresholds for marine mammals subject to underwater blasting. The new thresholds use Sound Exposure Level (SEL) and peak pressure (in dB) thresholds to establish areas of potential behavioral harassment, Level A harassment, or Level B harassment for marine mammals. The new thresholds establish different threshold criteria for underwater explosions compared to pile driving. This makes comparisons to the same sound exposure threshold difficult. However, the difference in the area of exposure for a threshold at which an effect may occur remains a valid comparison. As a result, comparison of the total acres affected over time for the exclusion zone thresholds for cofferdam construction is compared to the total acres affected over time for exclusion zone thresholds for the controlled implosion.

Hydroacoustic analysis of the Pier E3 implosion using the revised (2013) thresholds indicates the largest distance to the Level B Behavioral Harassment zone would be 13,564 meters (44,500

feet) for harbor porpoise (the most acoustically sensitive species). The distance to Level B (TTS) Harassment Zone for harbor porpoise was modeled at 8,077 meters (26,500 feet). However, the likelihood of this species occurring within the Bay during the implosion is very low and the species has not been detected within the project area during 210 days of marine mammal monitoring to date. However, real-time acoustic monitoring for harbor porpoises will be proposed in advance and during the implosion to ensure this species is not in the immediate area. For the species expected to be present around Pier E3 (i.e., harbor seal, California sea lion, and Northern elephant sea), the modeled distance to the Level B Behavioral Harassment zone was 2,957 meters (9,700 feet). The distance to the Level B (TTS) Harassment zone was 1,737 meters (5,700 feet), which does include known foraging areas for harbor seals at YBI, Clipper Cove, and southeast of YBI. The distance to the Level A (PTS or greater harm) Harassment zone, which reflects the implosion's marine mammal exclusion zone, for these species is 354 meters (1,160 feet). This distance could be effectively monitored under the existing marine mammal monitoring plan for the SFOBB Project. Inclusion of the Level B Behavioral Harassment Zone into the implosion's exclusion zone is not feasible due to the high probability that harbor seals will occupy known foraging areas near YBI and Clipper Cove. Prevention of Level B (TTS) exposure to individual seals within these areas could delay the implosion during a small window of opportunity.

The Pier E3 blast was modeled to potentially result in Level B (TTS) Harassment exposure to three Pacific harbor seals. This assessment is based on historic marine mammal densities in the exposure area and the implosion's duration of 5 to 6 seconds. In addition, six harbor seals, one Northern elephant seal, and one harbor porpoise would potentially be within the implosion's behavioral response zone. Through the implementation of exclusion zones and monitoring, no individuals would be subject to Level A (PTS or greater harm) Harassment.

The duration of potential exposure to marine mammals affected from cofferdam installation can be expressed as the product of the daily amount of acres affected multiplied by the number of days of effect. This value also can be interpreted as the cumulative amount of acres exposed during installation of a Pier E3 cofferdam. Table 4 presents cumulative acre information for marine mammal exposure under the assumption of one pile driven per day plus an estimated exposure to marine mammals from the controlled implosion. In reality, the 2012 BO's more restrictive pile-driving regulations for marine fish would likely limit the amount of pile driving allowed on a daily basis. However, for the sake of this comparative analysis we have ignored this limitation.

Table 4. Comparison of Marine Mammal Hydroacoustic Impacts from Pier E3 Cofferdam Installation versus Controlled Implosion

				Level B Behavioral Harassment Zone				Temporary Exclusion Zone (Level B [TTS] and Level A [PTS or greater harm] Harassment)			
Construction Approach	**METHOD**	**Pile Type**	**Days Required[1]**	**Acres Affected to 120 dB RMS (Per Pile)**	**Acres Affected to 120 dB RMS (Total)**	**Acres Affected to 160 dB RMS (Per Pile)**	**Acres Affected to 160 dB RMS (Total)**	**Acres Affected to 180 dB RMS (Per Pile)**	**Acres Affected to 180 dB RMS (Total)**	**Acres Affected to 190 dB RMS (Per Pile)**	**Acres Affected to 190 dB RMS (Total)**
Cofferdam Installation	Vibratory[2] Driving	24”	18	3,113	56,034	N/A	N/A	N/A	N/A	N/A	N/A
		Sheet Pile	170	3,113	529,210	N/A	N/A	N/A	N/A	N/A	N/A
	Attenuated Impact Driving	Bulkhead 54”	36	N/A	N/A	88	3,168	0.4	14.4	0.03	1.1
		King Pile	170	N/A	N/A	39	6,630	0.2	34	0.01	1.7
	Unattenuated Pile Proofing	24”	18	N/A	N/A	262	4,716	1.2	22	0.08	1.4
		Sheet Pile	85	N/A	N/A	200	17,000	0.9	76.5	0.06	5.1
	Totals[3]	-	**497**	**6,226**	**585,244**	**589**	**31,514**	**2.7**	**147**	**0.18**	**9.3**
				Level B Behavioral Harassment Zone (Total Acres Affected)[4]		**Level B (TTS) Harassment Zone (Total Acres Affected)[5]**		**Temporary Exclusion Zone (Level A [PTS or greater harm] Harassment) (Total Acres Affected)[6]**			
Controlled Implosion	Attenuated Implosion	NONE	**1**	**4,401**		**1,854**		**109**			

[1] Assumption that one pile per day can be driven or vibrated.
[2] Vibratory drilling does not generate enough noise to reach Level B or Level A Harassment
[3] Totals tally Total Acres
[4] Area is calculated to 172 dB SEL Criteria
[5] Area is calculated to 177 dB SEL Criteria
[6] Area is to calculated to 192 dB SEL Criteria