Application for Incidental Harassment Authorization for the Taking of Marine Mammals Under Section 101 (a)(5)(A) of the Marine Mammal Protection Act by the Jordan Cove Energy Project

Jordan Cove Energy Project, LP

Docket No. CP17-495-000

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Table of Contents

Appendices

Figures

Tables

Acronyms and Abbreviations

μPa	micropascal(s)
AECOM	AECOM Technical Services
APCO	APCO Coos Properties, LLC
CFR	Code of Federal Regulations
CM	Channel Mile
cSEL	cumulative sound exposure level
dB	decibel(s)
dBA	A-weighted decibel(s)
DPS	Distinct Population Segment
EEZ	exclusive economic zone
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FNC	Federal Navigation Channel
FR	Federal Register
ft/sec	feet per second
GIS	geographic information system
HMT	highest measured tide
Hz	hertz
IHA	Incidental Harassment Authorization
JCEP	Jordan Cove Energy Project, LP
kHz	kilohertz
LNG	liquefied natural gas
LNG Terminal	liquefied natural gas export terminal on the bay side of the North Spit of Coos Bay, Oregon
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MOF	material offloading facility
NAVD88	North American Vertical Datum of 1988
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRI	Navigation Reliability Improvements
ODFW	Oregon Department of Fish and Wildlife
OIMB	Oregon Institute of Marine Biology
Pipeline	Pacific Gas Connector Pipeline LP's 36-inch, 229-mile pipeline from an interconnection with the existing interstate pipeline systems of Ruby Pipeline LLC and Gas Transmission Northwest LLC near Malin in Klamath County, Oregon, and extending to the LNG Terminal
PTS	permanent threshold shift
RMS	root mean square
SEL	sound exposure level
SLR	SLR Consulting
SPL	sound pressure level
TMBB	temporary material barge berth
TPP	TransPacific Parkway
US-101	U.S. Highway 101
ZOI	Zone of Influence

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Introduction

In September 2017, Jordan Cove Energy Project, LP (JCEP) filed an application with the Federal Energy Regulatory Commission (FERC) under Section 3 of the Natural Gas Act to construct and operate a liquefied natural gas (LNG) export terminal on the bay side of the North Spit of Coos Bay, Oregon (LNG Terminal). The LNG Terminal would be capable of receiving and loading ocean-going LNG carriers, to export LNG to Asia markets, and sized to export 7.8 million metric tons of LNG per annum.

Pacific Gas Connector Pipeline, LP is seeking authorization from FERC under Section 7 of the Natural Gas Act to construct and operate a 36-inch pipeline that would extend approximately 229 miles (Pipeline); starting from an interconnection with the existing interstate pipeline systems of Ruby Pipeline LLC and Gas Transmission Northwest LLC near Malin in Klamath County, Oregon, and extending to the LNG Terminal. The Pipeline is designed to transport up to 1,200,000 dekatherms per day of natural gas at a maximum allowable operating pressure of 1,600 pounds per square inch gage. Construction and operation of the Pipeline will not contribute noises that could exceed the National Marine Fisheries Service (NMFS) thresholds for marine mammals.

Because the type of activities that would be undertaken to construct the LNG Terminal and related activities could result in the incidental harassment of marine mammals, JCEP is requesting issuance of an Incidental Harassment Authorization (IHA) by the National Oceanic and Atmospheric Administration (NOAA), NMFS under Section 101(a)(5)(A-D) of the Marine Mammal Protection Act of 1972 (MMPA), as amended, 16 U.S. Code Section 1371(a)(5). This IHA application requests incidental take for the following seven species:

- Pacific harbor seal (*Phoca vitulina*)
- Northern elephant seal (*Mirounga angustirostris*, California Breeding Stock)
- California sea lion (*Zalophus californianus*)
- Steller sea lion (*Eumetopias jubatus*, Eastern Distinct Population Segment [DPS])
- Gray whale (*Eschrichtius robustus*, Eastern North Pacific DPS)
- Killer whale (*Orcinus orca*–transient population)
- Harbor porpoise (*Phocoena phocoena*)

None of the stock populations of these seven species potentially found in Coos Bay are listed as threatened or endangered under the Endangered Species Act (ESA).

The MMPA prohibits (with some exceptions) the “taking” of marine mammals by any person. “Take” is defined as “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal” (16 U.S. Code Section 1362913). The MMPA defines harassment as “any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering” (16 U.S. Code Section 1362[18]). Harassment under subclause (i) constitutes Level A harassment, while harassment under subclause (ii) constitutes Level B harassment. Level B harassment does not have the potential to permanently injure a marine mammal or marine mammal stock in the wild.

Section 101(a)(5)(D)(i) of the MMPA provides a mechanism for allowing, on request, the incidental but not intentional taking by harassment of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) in a specified geographic region, provided the takings would have a negligible impact on such species or stock, 50 Code of Federal Regulations (CFR) §216.101. These regulations prescribe:

- Permissible methods of taking by harassment, and other means of causing the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance; and
- Requirements for monitoring and reporting.

This IHA application seeks approval for the incidental harassment of a small number of marine mammals resulting from construction of the LNG Terminal. The primary noise sources that could result in the take of the species listed above include vibratory and impact driving of sheet and pipe piles and are discussed in detail in Section 1. Subsequent sections include pertinent information as required by 50 CFR §216.104(a).

To ensure the least practicable impact on marine mammal species, JCEP has devised the construction sequence to minimize the impacts from construction of the LNG Terminal on marine mammals; reduce the total period of estuary turbidity; and extend the time available for construction. JCEP would construct the slip in three distinct groups: dry, wet–freshwater, and wet–saltwater. The basic concept of this construction sequence would be to excavate the majority of the slip and construct the associated structures while maintaining a natural earthen berm barrier to physically partition Coos Bay from the slip area and other LNG Terminal construction activities. This construction method would allow year-round work on the bulk of the slip without the construction activities being in contact with or causing potentially adverse impacts on marine mammals or other marine life that may be present in Coos Bay. Retaining the berm for the majority of the construction is the primary in-water direct and indirect avoidance and minimization measure for the LNG Terminal.

JCEP would minimize in-water sound production by implementing additional minimization measures, such as using vibratory drivers to fully install sheet piles; using a vibratory driver to install pipe piles to the maximum extent practicable; and installing all in-water pipe piles with an impact hammer during the Oregon Department of Fish and Wildlife (ODFW) regulated in-water work window, which would avoid harbor seal pupping season (October 1 through February 15). In addition, JCEP would implement a robust monitoring program to assess impacts and record authorized take during those construction activities that are anticipated to result in noise levels that could exceed the applicable marine mammal thresholds.

1. Description of Specified Activity

"A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals". (50 CFR Section 216.104[a][1])

1.1 Project Overview

The project would be constructed in Coos Bay in southern Oregon. The main components of the project would include:

- The LNG Terminal and associated facilities in Coos County, Oregon;
- Construction activities related to the LNG Terminal construction but occurring at other locations in Coos Bay, hereafter referred to as Ancillary Activities; and
- The Pipeline, which will cross portions of Klamath, Jackson, Douglas, and Coos counties in Oregon, and associated facilities.

The construction and operation of the Pipeline would not generate noise levels that could exceed NMFS thresholds or otherwise harass marine mammals, and thus they are not discussed further in this IHA application.

1.2 LNG Terminal

The LNG Terminal site is in Coos County, Oregon, on the bay side of the North Spit of Coos Bay at about Channel Mile (CM) 7.3, along the existing federal navigation channel. The LNG Terminal is located in what is referenced as Ingram Yard in Figure 1-1 and would include a gas conditioning plant, a utility corridor, liquefaction facilities (including five liquefaction trains), two full-containment LNG storage tanks, and LNG loading facilities. These land-based components are not described in greater detail because no activities occurring in these locations would generate sound levels that could result in take of marine mammals. The LNG Terminal also would include a marine slip, access channel, material offloading facility (MOF), and temporary materials barge berth (TMBB), collectively referred as the Marine Facilities.

1.2.1 Marine Slip

The marine slip would include the LNG carrier berth, west lay berth, a tsunami protection wall, a retaining wall, an LNG loading platform, and a tug dock. The new marine slip would be constructed by excavating an existing upland area, keeping an earthen berm on the southern side intact during construction. The marine slip would be separated from the waters of Coos Bay by the earthen berm. The earthen berm would be removed during the last year of construction.

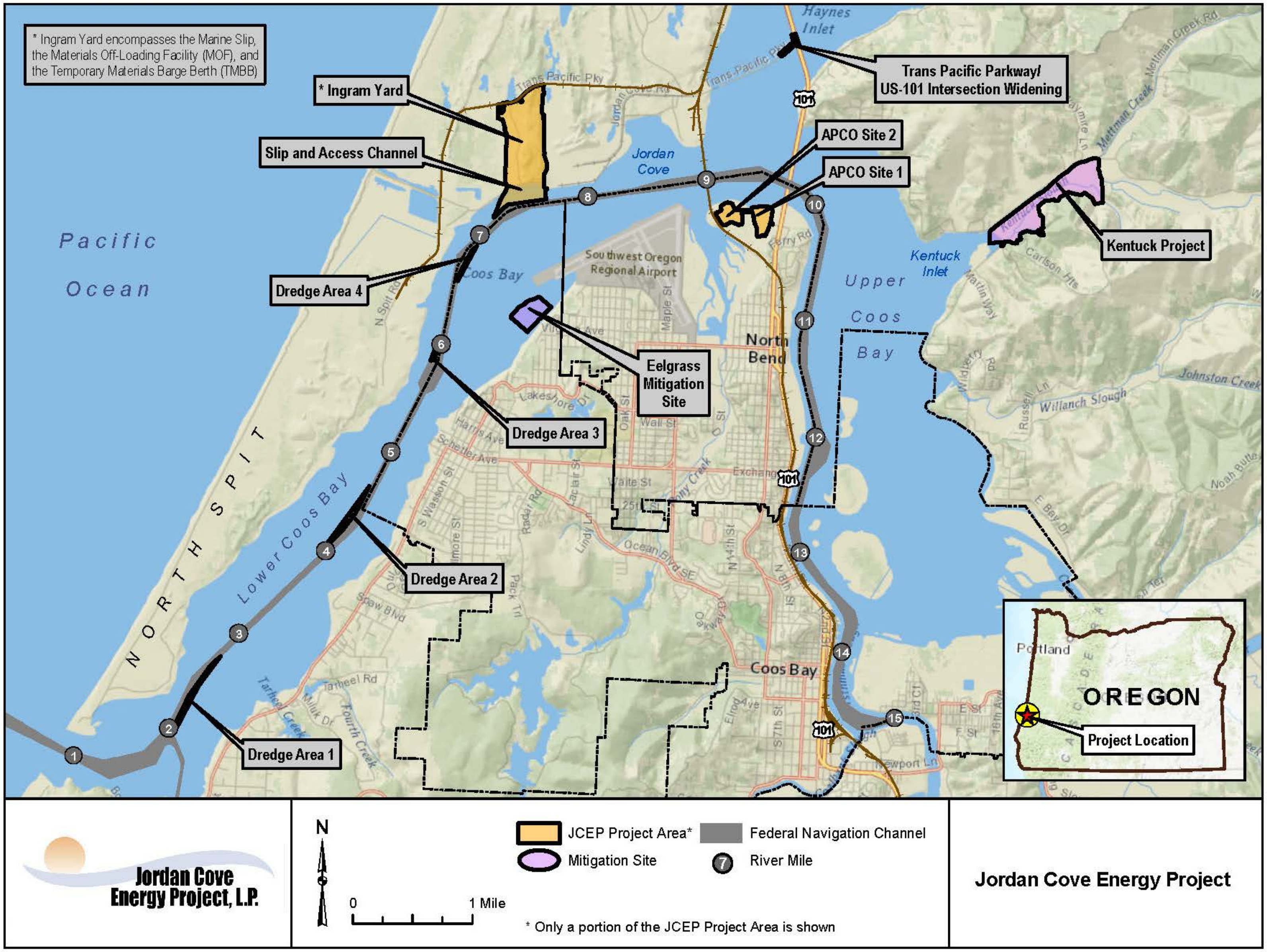


Figure 1-1. Site Location Map

The eastern and western sides of the slip would be formed from sheet pile walls. The sheet piles that would be installed at these locations are designed to be driven “in the dry,” to ensure structural integrity. To form these walls, sheet piles would be driven with a vibratory hammer into sandy soils that have been loosened with an auger drill prior to piling. The sheets would be installed in the upland area before excavating the material that eventually would be on the waterside of the sheet pile walls (i.e., “in the dry”); therefore, noise transmitted directly through water would be eliminated, and noise indirectly reaching the marine environment would be greatly reduced or eliminated. In addition, sheet piles would extend along the southwestern corner, beyond the marine slip. The construction methodology for this area would be similar to the eastern and western walls in the slip (i.e., “in the dry” construction). For those piles that would be installed in the dry but near the shoreline (e.g., the sheet piles at the southwestern wall or the MOF face), noise may indirectly propagate into the water.

1.2.2 Access Channel

The access channel (Figure 1-2) would be dredged north of the Federal Navigation Channel (FNC) to provide LNG carriers access from the FNC to the slip. The walls of the access channel would be sloped to meet the existing bottom contours, at an angle of 3:1. The access channel would cover approximately 30 acres below the mean higher high-water line, or highest measured tide line (Figure 1-2). Approximately 1.4 million cubic yards (MCY) of primarily densely packed fine-grained sand with traces of silt would be dredged from the bay for the access channel. See Figure 1-2 for the dredging limits of the access channel. This work would be performed during the ODFW regulated in-water work window, between October 1 and February 15.

1.2.3 Material Offloading Facility

JCEP would construct a MOF to be used primarily for delivery of large and heavy material and equipment shipments during construction that cannot be transported by rail or road. The MOF would cover about 3 acres on the southeastern side of the slip, and vessels calling at the MOF also would use the access channel for navigation and berthing (Figure 1-2). The MOF would be constructed using the same construction methods and sheet pile wall system as the eastern and western sides of the slip (see Section 1.2.1). The top of the MOF would be at elevation 13 feet North American Vertical Datum of 1988 (NAVD88), and the bottom of the exposed wall would be at the access channel elevation (-45 NAVD88 or -45 feet mean lower low water [MLLW]). The MOF would provide approximately 450 linear feet of dock face for the mooring and unloading of a variety of vessel types.

After construction, the MOF would be retained as a permanent feature of the LNG Terminal, to support maintenance and replacement for equipment components that are too large to be transported by rail or road. Additional construction sequence details are provided below.

1.2.4 Temporary Materials Barge Berth

The TMBB would be an offloading facility that would be cut from the shoreline area near the western edge entrance to the slip (Figure 1-2), to facilitate early construction activities. A section large enough to receive and moor the end of an ocean-going barge would be excavated. Following the excavation work, up to six mooring piles would be installed. Piles would be vibrated in, to the maximum extent possible, and then would be impact-driven to depth if necessary. All piles would be installed within the footprint of the earthen berm and not driven in open water (i.e., in the dry). These piles would be removed during the berm excavation to open the slip.

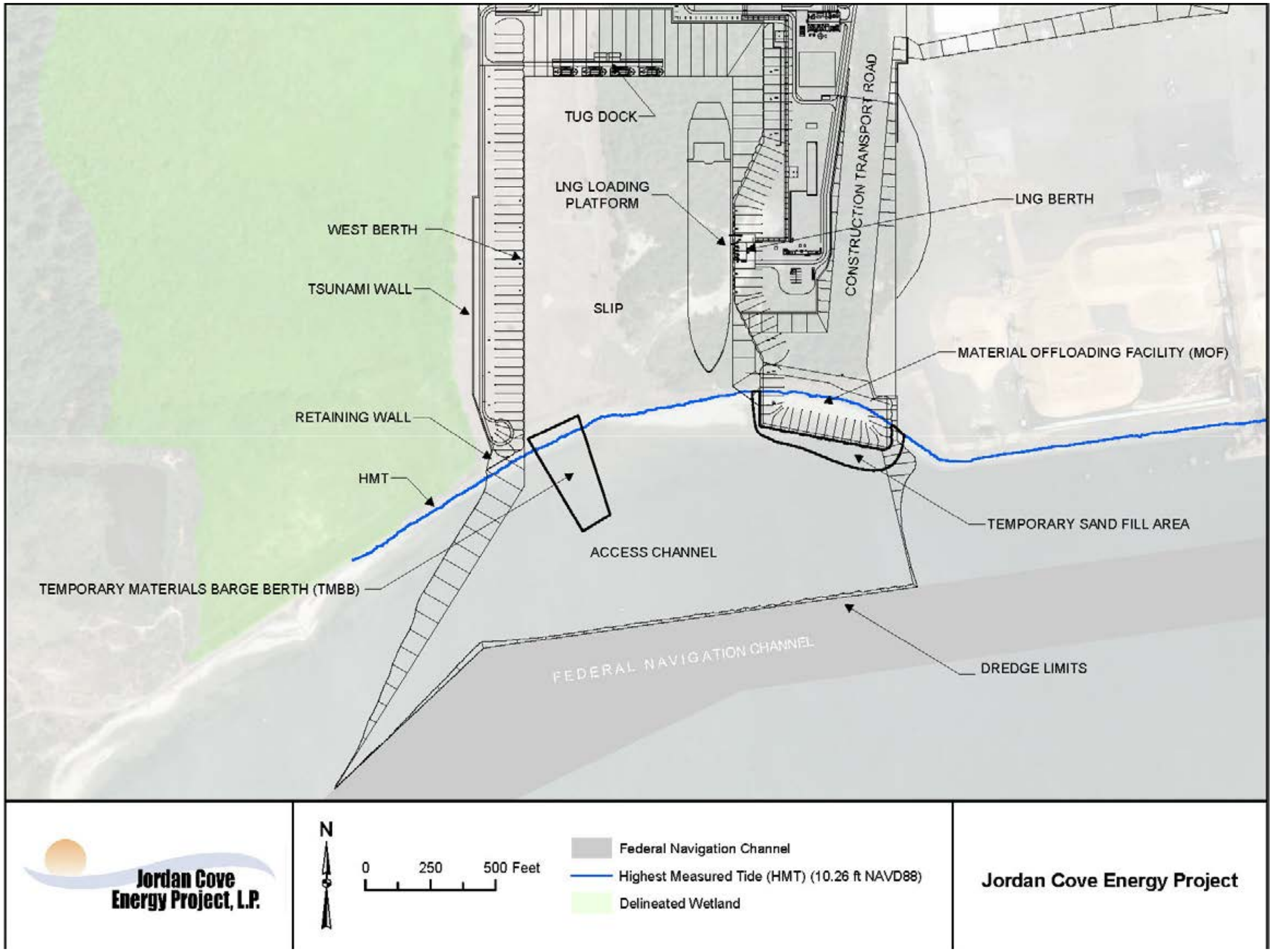


Figure 1-2. Plot Plan of LNG Terminal - Marine Facilities

1.3 Ancillary Activities

Below is a description of the Ancillary Activities associated with the LNG Terminal.

1.3.1 Navigation Reliability Improvements (NRI)

Four permanent dredge areas adjacent to the FNC would allow for navigation efficiency and reliability for vessel transit under a broader weather window (labeled as Dredge Areas 1 through 4 on Figure 1-1).

Each of the NRI areas (i.e. Dredge Areas) consists of expanding the depth immediately adjacent to an existing channel turn or bend. The four locations have been identified as requiring dredging of approximately 372,900 cubic yards (CY) of material, of which the majority is very soft sandstone or siltstone and the rest is sand.

- Dredge Area 1 – JCEP proposes to widen the Coos Bay channel from the current width of 300 feet to 450 feet, thereby making it easier for all vessels transiting the area to make the turn into the estuary. In addition, the total corner cutoff on the Coos Bay Range side would be lengthened from the current 850 feet to about 1,400 feet from the turn's apex.
- Dredge Area 2 – The current corner cutoff distance from the apex of this turn is about 500 feet, making it difficult for vessels to begin turning sufficiently early to be able to make the turn and be properly positioned in the center of the next channel range. JCEP proposes to widen the turn area from the Coos Bay Range to the Empire Range from the current width of 400 feet to 600 feet at the apex of the turn and lengthen the total corner cutoff area from the current 1,000 feet to about 3,500 feet.
- Dredge Area 3 – JCEP proposes to add a corner cut on the west side in this area that would be about 1,150 feet, thereby providing additional room for vessels to make this turn.
- Dredge Area 4 – JCEP proposes to widen the turn area here from the current 500 feet to 600 feet at the apex of the turn and lengthen the total corner cutoff area of the turn from the current 1,125 feet to about 1,750 feet, thereby allowing vessels to begin their turn in this area earlier.

Table 1-1 provides a summary of the material to be removed at each location.

Table 1-1. NRI Dredge Summary

Dredge Area	Channel Mile	Estimated Dredge Volume (CY)	Material Type
1	2	254,900	Sand overlying soft sandstone
2	4	108,400	Sand overlying Soft Siltstone / Sandstone.
3	6	7,150	Sand overlaying a highly localized area of soft to hard sandstone.
4	6 to 7	2,450	Sand
	Total	372,900	

Two methods of dredging are identified as the most practical, given the historical dredging practices in the region, the material types being dredged, and the location and condition of the placement sites. The primary method utilized will be hydraulic cutter suction dredging, but mechanical dredging via clamshell or excavator is also likely to be used to a limited extent. Dredging at the NRIs will not occur during Year 1 of construction.

1.3.2 TransPacific Parkway (TPP) and U.S. Highway 101 (US-101) Intersection Widening (TPP/US-101)

The asymmetrical widening of TPP to the north and US-101 to the west, to provide safe ingress/egress for construction traffic by creating a left-turn lane from TPP onto northbound US-101 and a right-turn lane from US-101 onto TPP.

1.3.3 APCO Coos Properties, LLC (APCO) Sites

APCO Site 1 (east) and APCO Site 2 (west) would be used as upland dredge disposal sites for the LNG Terminal construction.

1.3.4 Kentuck project site

An approximately 100-acre proposed wetland mitigation and habitat restoration site associated with the LNG Terminal. The objective for the Kentuck site would be to re-establish tidal influence to approximately 100 acres of historical intertidal habitats in a former golf course site, to re-establish the floodplain connection to approximately 2.5 acres of historical floodplain adjacent to Kentuck Creek (Figure 1-1), and to establish a mix of primarily forested and scrub-shrub wetland habitats. The restoration would require approximately 300,000 cubic yards of material to be transported from the dredge activities in the slip area of the LNG Terminal to the Kentuck site via marine transport barges.

1.3.5 Eelgrass Mitigation site

To offset potential loss of eelgrass resulting from excavation of the access channel, approximately 6 acres of intertidal habitat would be enhanced to support approximately 2 acres of medium or higher density eelgrass beds, and approximately 4 acres of low-density eelgrass beds. This Eelgrass Mitigation site is adjacent to the Southwest Oregon Regional Airport (Figure 1-1). To allow offloading of restoration materials that are transported to the site by vessel, an ocean-going receiving barge would be moored temporarily at the site.

Each of the Ancillary Activities listed above would require pile driving. Only the activities at the TPP/US-101 and APCO Sites would occur during the first year of construction. The NRIs, Kentuck and Eelgrass Mitigation sites would not be active until the offloading sites have been prepared to take the dredge material. Additional details are provided in subsequent sections of this application.

1.4 Activities Not Expected to Result in Take

Construction of the LNG Terminal would require delivery of large, prefabricated modules, other construction components and material brought to the site by ocean-going vessels and offloaded at the MOF, before construction of the MOF and the TMBB. The barges and tugs would be operating at sufficiently low speeds that ship strikes would not occur. Based on the marine traffic that currently uses the FNC on a regular basis, the additional barges and tugs used to deliver components for the LNG Terminal on an irregular and intermittent basis would not cause ambient sound levels to increase measurably. Shipment of the modules and other construction materials would not result in harassment of marine mammals.

The land-based components of the LNG Terminal would be located east and north of the slip, and would include the gas conditioning plant, a utility corridor, liquefaction facilities, and LNG storage tanks. For the majority of the marine slip construction, an earthen berm would be kept in place to isolate the excavation and work area from the waters of Coos Bay. This construction method would greatly reduce the potential for turbidity impacts on Coos Bay and would greatly reduce the amount of pile driving that would occur in or near the waters of Coos Bay.

Aside from specific portions of the LNG Terminal construction discussed in Section 1.2 and the Ancillary Activities discussed in Section 1.3, the other LNG Terminal construction, including a majority of pile driving, would be well removed from the shores of Coos Bay. Therefore, no take is being requested for these activities, and they are not discussed further in this application.

1.4.1 In-the-Dry Drilling – Auger Method

During sheet piling for the marine slip and MOF, soil would first be loosened with an auger prior to installation of the sheet piles. This drilling would be done in the dry. This augering does not use any percussive force and is not expected to generate vibration that may translate into underwater noise in excess of NMFS thresholds in the nearby waters of Coos Bay. In-water geotechnical boring, which is a similar non-percussive drilling method, produces sound levels of 145 dB or less at 1 meter (Erbe and McPherson 2017). Since this augering would occur in-the-dry and at 10 meters or more from the water's edge, noise levels in Coos Bay from augering are expected to be far less than 120 dB RMS.

1.4.2 Dredging Activities

As part of construction of the LNG Terminal and several of the Ancillary Activities, dredging would be undertaken by JCEP, as described in Section 1.2.2 and 1.3. With the exception of the new Access Channel to the Marine Terminal (Figure 1-2), dredging would occur adjacent to the current FNC or at the restoration sties.

The USACE regularly conducts maintenance dredging of the FNC, with varying portions of the channel being dredged each year. Current practices include yearly maintenance dredging with up to five feet of advance maintenance dredging at the Entrance Channel and up to three feet in the Main Channel (RM 1 to 15); this is in addition to an allowable overdepth of three feet (USACE 2015). The FNC is maintained by the USACE Portland District, using hopper dredges downstream of CM 12 and clamshell dredging upstream CM 12. Pipeline (hydraulic) dredging is used less extensively. Material dredged during routine channel maintenance generally consists of 700,000 to 1,100,000 CY of sand annually. Assuming a typical dredge rate of 30,000 CY per day (Wowtschuk 2016), the USACE annual dredging takes 23 to 37 days of continuous dredging. In addition to the FNC, dredging of marina facilities by other parties occurs intermittently throughout the bay.

In Coos Bay and other regularly dredged estuaries such as San Francisco Bay, harbor seal haul-out use has been relatively stable, with no indications that dredging is having a negative impact on harbor seal populations. This stability indicates that harbor seals may be accustomed to dredging noise in areas where it occurs regularly. Additionally, large vessels, such as those that currently operate in the estuary, produce underwater noise with a similar magnitude and frequency range to dredging noise (McQueen et al. 2018) as they traverse the FNC. For example, tugs pushing a barge at 18km/hr produce noise levels of around 171 dB at 1 meter

(Richardson et. al. 1995), which is similar to noise levels reported for a cutter suction dredge and louder than a mechanical dredge (McQueen et al. 2018).

Observational studies of pinnipeds have not detected avoidance or altered behavior near dredging activities (McQueen et al. 2018). The dredging associated with JCEP would occur 500 meters or more from all established haul-out sites, therefore animals coming and going from the immediate vicinity of the haul outs would not likely be impacted by the dredging activities. The estuary is, on average, over 0.5-mile-wide which would allow animals transiting up and down the estuary space to avoid the area, if necessary.

The NRI dredging would also take place during the in-water work window and thus avoid the pupping season of harbor seals, when they may be more sensitive to disturbance. Due to these factors, dredging is not anticipated to result in noise levels that would harass or cause behavioral changes in marine mammals, nor is visual disturbance anticipated to deter animals from using existing haul-outs in the estuary; therefore, dredging would not result in take of marine mammals.

1.4.3 Schedule of Dredging Activities

The planned dredging would take place over several of the ODFW regulatory in-water work windows during the construction period. The in-water work window is the period of October 1 to February 15, and the period outside the in-water work window is February 16 to September 30. The proposed dredging schedule is as follows.

- **Year 1 in-water work window dredging:** TMBB and other initial dredging at the Access Channel;
- **Year 2 in-water work window dredging:** Access Channel dredging, Eelgrass Mitigation site deepening, NRI Dredge Area 1 and 3;
- **Year 3 in-water work window dredging:** NRI Dredge Area 2;
- **Year 4 in-water work window dredging:** NRI Dredge Area 4.

Due to the logistical constraints of offloading dredge material at APCO Sites 1 and 2, only one of the NRI sites can be dredged at any given time. All dredged materials will be used as fill for restoration of the Kentuck site, disposed of at APCO Sites 1 and 2, or placed in an upland location. There will be no at-sea disposal of dredge material.

1.5 Activities Expected to Result in Take

For this IHA application, a portion of the pile driving associated with construction of the LNG Terminal could exceed the NMFS in-water acoustic thresholds (NMFS 2018). Only those piles driven directly in Coos Bay or near the water's edge (within approximately 30 meters of the shoreline but still in-the-dry) may produce underwater noise that exceeds NMFS thresholds and could result in take of marine mammals. For construction of the LNG Terminal, pile driving with the potential to result in take of marine mammals would occur during the Year 1 construction season for:

- TMBB mooring piles,
- Sheet piles for the MOF wall, and

- Sheet piles for the southwestern end of the West Berth wall.

Details of the activities requiring pile driving at the LNG Terminal are presented in subsequent sections. Pile driving occurring in Years 2 and 3 will be addressed in future IHA applications. In addition, JCEP would undertake Ancillary Activities that would involve pile driving that may produce noise levels exceeding NMFS thresholds. The Ancillary Activities involving pile driving in Year 1 would include:

- Construction for widening of the TPP/US-101 intersection, and
- Construction for preparation of the APCO off-site disposal sites.

Additional pile driving activities will be undertaken during Years 2 and 3 and will be addressed in subsequent IHA applications.

1.5.1 LNG Terminal Pile Driving Activities

Because of soil characteristics and engineering requirements, the full LNG Terminal would require installation of more than 3,600 pipe piles and nearly 11,800 sheet piles, with roughly 570 pipe piles and 10,000 sheet piles being installed for construction of the marine slip, MOF, and TMBB. As discussed above, of the total piles that would be installed at the marine slip, a large majority would be installed far from the waters of Coos Bay, in upland areas or behind an earthen berm. The following discussion is specific to pile driving that may generate sound levels exceeding NMFS thresholds during the Year 1 construction season (see Figure 1-3).

1.5.1.1 LNG Terminal - Pipe Pile Driving

Pipe piles associated with the LNG Terminal would be installed in Year 1 at the TMBB and would be near the water's edge (in the dry). No in-water pipe piles will be installed at the LNG Terminal in Year 1.

The TMBB would be constructed within the footprint of the future marine slip and access channel (Figure 1-3). The TMBB would be used until the MOF is able to receive materials. A section of the shoreline large enough to receive and moor the end of an ocean-going barge would be removed and would be excavated down to elevation -12 MLLW. Following the excavation work, a crane would be used to vibratory-drive six 24-inch steel mooring piles within the earthen berm near the shoreline. Land-based mobile cranes with pile-driving equipment would be situated on the land side of the earthen berm or situated on the earthen berm to facilitate pile driving. These piles would be removed during the berm removal, to open the slip using a vibratory extractor. The berm removal is scheduled during the final year of construction (Year 3).

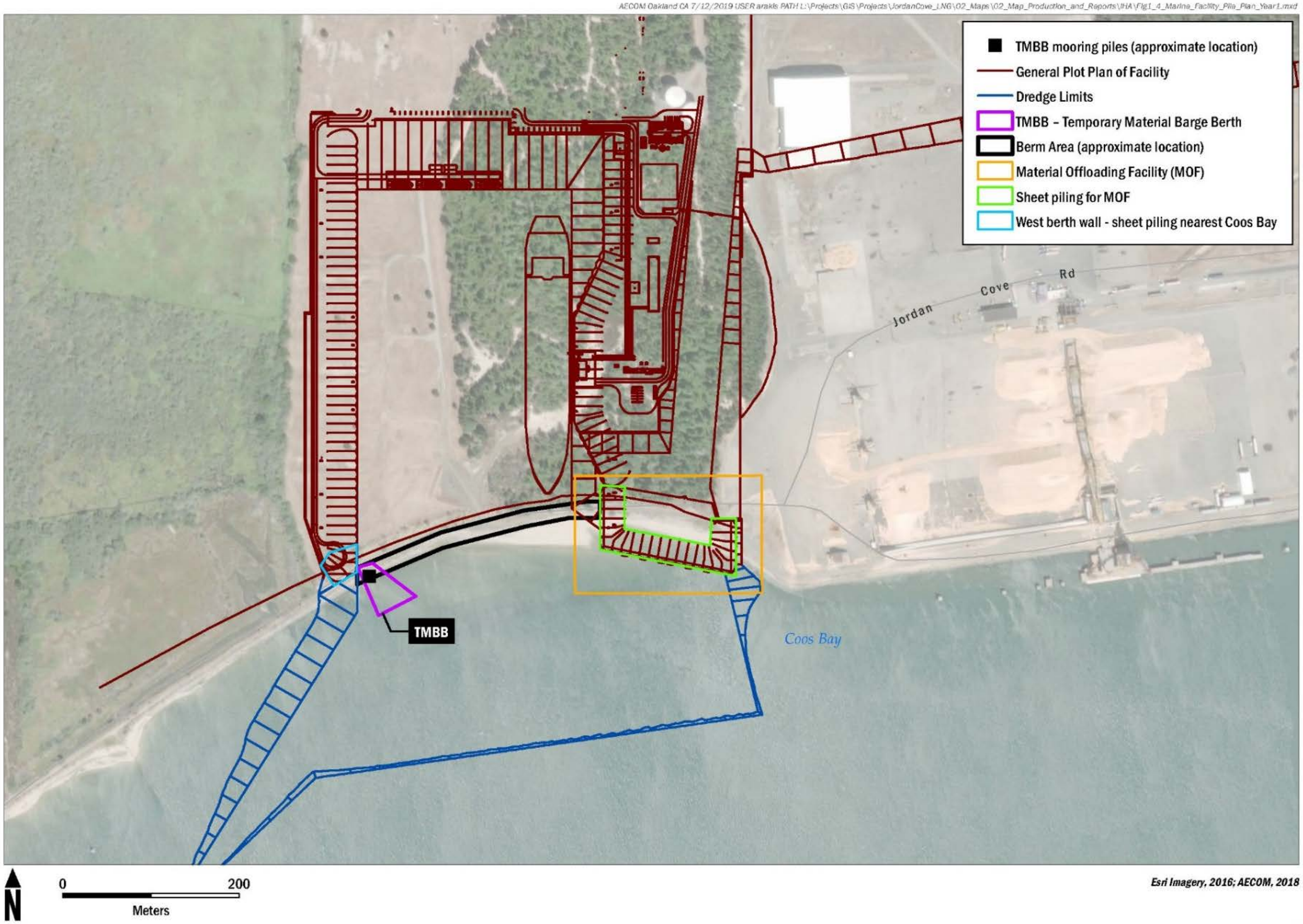


Figure 1-3. LNG Terminal Pile Plan – Year 1

1.5.1.2 LNG Terminal - Sheet Pile Driving

The eastern and western faces of the slip and the entire MOF face would be created with interlocking sheet piles. All sheet piles would be installed into land by vibratory installation. Only the sheet piles for the MOF and the southern-most end of the western slip face would be installed near enough to the water's edge to generate underwater noise that may exceed NMFS thresholds (Figure 1-3).

MOF construction would be sequenced as follows (Figure 1-4):

- Earthwork equipment would cut soil from the southern portion of the existing dune. Clean sand would be placed in the adjacent waterway, to create a work platform extending outside the MOF footprint. Riprap or other suitable material would be placed temporarily on the face of the slope, to protect sandy material from tidal erosion.
- Using the placed fill to position construction equipment, sheet piles would be driven near the edge of Coos Bay, but without direct contact with the marine environment, but close enough that noise may be generated into the water indirectly.
- Material from the front of the MOF would be removed to achieve operational depth requirements after the sheet piles have relaxed and locked into place. After the sheet piles have relaxed, a topping-off operation would occur behind the sheet pile wall to approximate elevation +13 (NAVD88) before concrete and rock are placed on top of the MOF.

1.5.1.3 Pile Driving Associated with the LNG Terminal—Summary

Table 1-2 summarizes the pile driving associated with the LNG Terminal, described above. This summary captures only the pile driving activities that will be conducted during the 2020-2021 construction season (Year 1).

Table 1-2. LNG Terminal Pile Driving Summary

Pile Driving Activity	Pile Type	Size	Number of Piles	Number of Piles Driven per Day	Driving Type	In-the-dry or In-water?
TMBB	Pipe	24-inch	6	~1	Vibratory	In-the-dry
MOF	Sheet	NA	1,869	~13	Vibratory	In-the-dry
West Berth Southwest Wall (~2.5% closest to Coos Bay)	Sheet	NA	113	~13	Vibratory	In-the-dry

NA = Not applicable

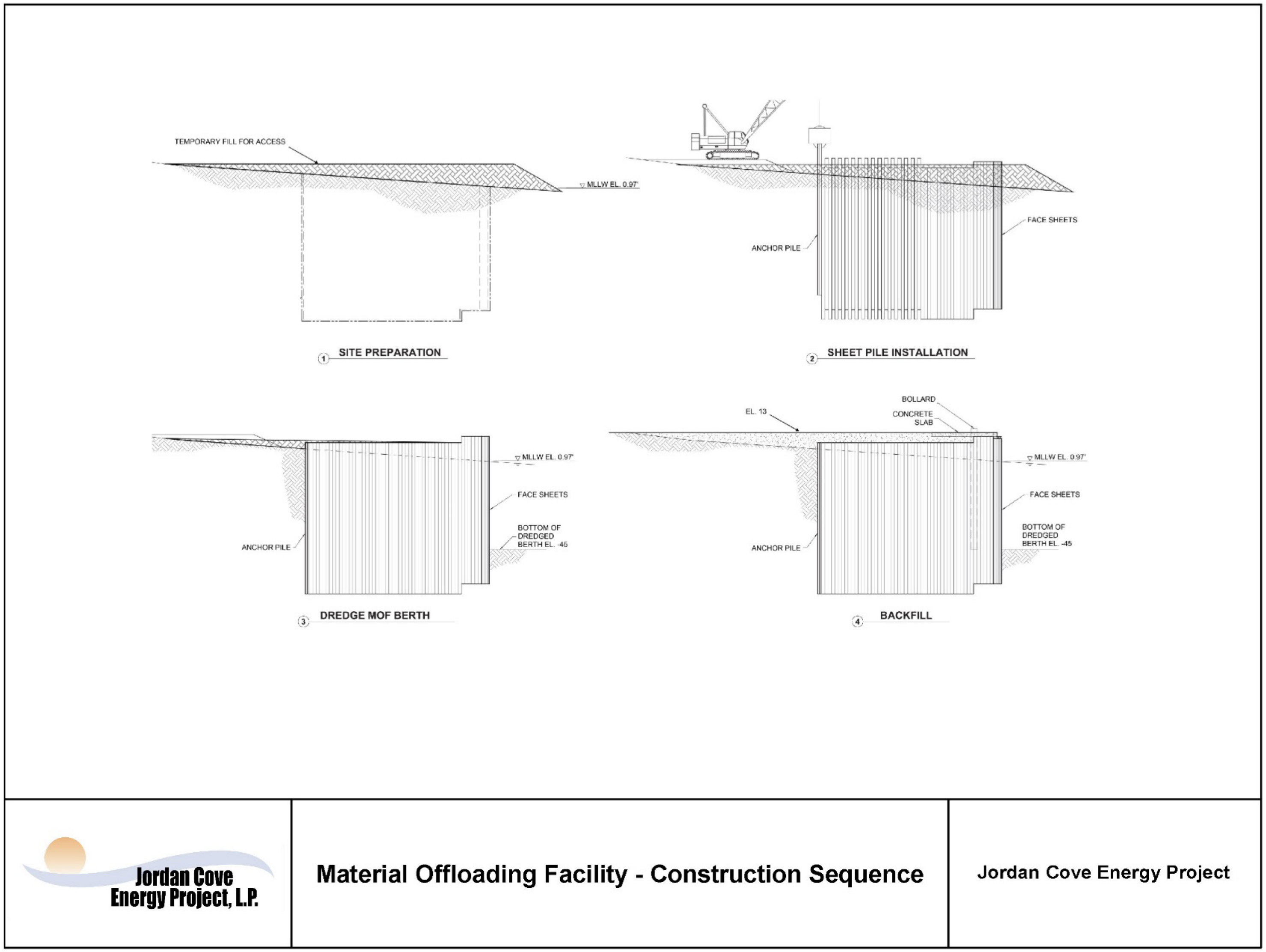


Figure 1-4. Material Offloading Facility Construction Sequence

1.5.2 Ancillary Activities

JCEP also would undertake a variety of other activities, not directly associated with the main project construction at the LNG Terminal. These activities, known as Ancillary Activities, would include dredging the NRIs, performing upgrades to the TPP/US-101 interchange, preparing APCO Sites 1 and 2, and implementing two mitigation programs to offset environmental impacts (Kentuck and Eelgrass Mitigation sites). All five of these activities would require pile driving, which could create noises in the marine environment that could be perceived by marine mammals, however only activities at the TPP/US-101 and APCO Sites will be occurring during Year 1. The following sections describe in more detail the pile driving associated with these two sites.

1.5.2.1 TransPacific Parkway/US-101 Intersection Widening

Traffic surveys and studies of projected construction traffic have determined that the intersection of US-101 and TPP (Figure 1-1) would need to be improved to accommodate delivery of materials for construction and operation. These improvements would involve widening the TPP on the northern side to provide a left-turn lane onto northbound US-101, a wider turning radius from southbound US-101 onto the TPP, two 12-foot-wide travel lanes, a 14-foot-wide left-turn lane and widened shoulders with guardrails. The road bases of both the TPP and US-101 are berms with two openings: one at the western end of TPP before it reaches land (approximately 90 meters wide) and one south of TPP along US-101 (approximately 210 meters wide). All the construction work related to the road improvements will be on the inside of the embayment of the road berms with limited connectivity to the rest of the Bay.

Embankment widening on the northern side of the causeway would be supported with a grid of approximately 1,150 untreated timber pilings. No treated timbers would be used. The untreated timber piles would be approximately 30 feet long and 14 inches in diameter at the top. The grid of timber pilings would be capped with a riprap embankment, providing a foundation to widen the roadway to the north. The timber pilings would be driven into the Bay mud using a vibratory and impact hammer within a temporary, outer sheet pile “work isolation containment system” (cofferdam). The sheet pile cofferdam would be installed with a vibratory hammer, and the work area would be surrounded by a turbidity curtain.

To create the cofferdam, approximately 311 sheet pile sections would be installed over approximately 11 days of pile-driving. The cofferdam is expected to be in place for approximately 1 year. After construction in the cofferdam is completed, the sheet piles would be cut at the mudline during low tides in the ODFW regulated in-water work window, using a crane on the shoulder of the TPP. Removal of the cofferdam would be done during the Year 2 construction season.

To construct the timber pile grid, the contractor would construct a work access bridge as pile driving progresses parallel to the TPP, on the inside of the bermed road. The work bridge would consist of thirty-six 24-inch piles. The piles would be installed using a combination of vibratory and impact driving. A bubble curtain attenuator (BCA) would be used during impact driving as these piles will be in-water piles and installed during the ODFW in-water work window. The work bridge would be temporary and would be in place for approximately 1 year. Pile removal would be done using vibratory methods or cutting below the mudline during the Year 2 construction season.

1.5.2.2 APCO 1 and APCO 2 Sites—Dredged Material Disposal Site Preparation

A primary location for disposal of dredged material from the NRIs would be at two APCO sites (APCO Site 1 and APCO Site 2, collectively referred to as the APCO sites) east of the Southwest Oregon Regional Airport (Figure 1-5.) Management of dredge material at the APCO sites would require construction of a single-lane permanent bridge, and a temporary bridge would be needed to construct the permanent bridge.

The temporary work bridge would be approximately 30 feet wide and 280 feet long, would begin and end on dry land, and would require installation of twelve 24-inch-diameter steel piles below the highest measured tide (HMT) boundary. These would be in-water piles and would be installed during the ODFW in-water work window. Steel piles would be driven with a vibratory hammer to minimize the potential impacts on marine mammals. The piles may be tested with impact pile drivers to determine whether they have been set properly. If impact driving is necessary for installation due to substrate conditions, a BCA would be used. The temporary work bridge would be in place for less than 24 months and would be removed using vibratory methods.

The permanent bridge would be 200 feet long and nearly 40.5 feet wide, would span the tidal mudflat, and would provide access to and from the disposal sites. Because the permanent bridge would span the tidal mudflat, no in-water pile driving would be required for its construction.

If dredged material is offloaded from a barge/scow, a temporary dredge offload facility would need to be constructed, to hydraulically transfer dredge material. Approximately 16 temporary in-water piles and/or spuds that would be 24 inches in diameter would be used to moor the facility and barges, depending on actual equipment and configuration. Additionally, the Temporary Dredge Transfer Line will need to be placed across an eelgrass bed at the APCO sites to minimize impacts, so a support cradle for the Temporary Dredge Transfer Line will be needed which will require five 24-inch temporary piles. These will be installed with a vibratory hammer during the in-water work window.

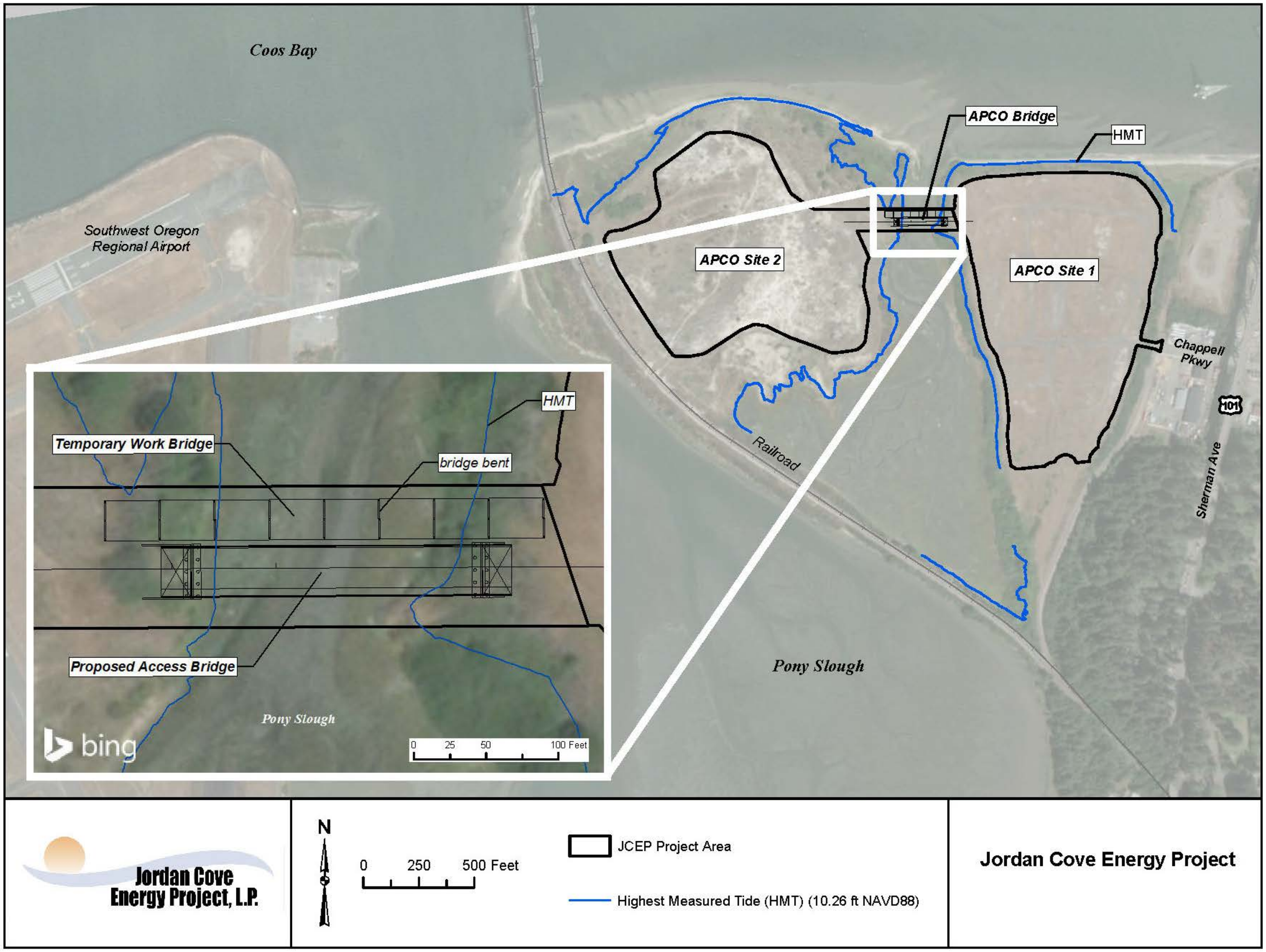


Figure 1-5. APCO Sites Layout

1.5.2.3 Pile Driving Associated with Ancillary Activities—Summary

Table 1-3 summarizes the pile driving associated with the Ancillary Activities, described in Section 1.5.2. Only the installation of piles associated with the TPP/US1010 Widening and APCO Sites 1 and 2 would occur during the Year 1 construction season. All piles would be driven in the water except for the timber piles at the TPP/US-101, which will be driven behind a partially dewatered cofferdam. All impact driving of pipe piles will be done within a bubble curtain and driven during the ODFW in-water work window.

Table 1-3. Ancillary Activities Pile Driving Summary – Year 1

Ancillary Activity	Pile Type	Size	Number of Piles	Piles Driven per Day	Driving Type
TPP/US-101 Widening					
Roadway Grid	Timber	14-inch	1,150	20	Impact
Cofferdam	Sheet	NA	311	20	Vibratory
Work Access Bridge	Pipe	24-inch	36	4	Vibratory and Impact
APCO 1 and APCO 2 Sites					
Temporary Work Bridge	Pipe	24-inch	12	4	Vibratory
Dredge Line Support Cradle	Pipe	24-inch	5	4	Vibratory
Dredge Offloading Area	Pipe	24-inch	16	4	Vibratory

Notes:
NA = Not applicable

2. Dates and Duration, Specified Geographic Region

"The date(s) and duration of such activity and the specific geographical region where it will occur." (50 CFR Section 216.104[a][2])

2.1 Dates and Duration

JCEP currently anticipates that construction for the LNG Terminal would begin in the second half of 2020, with a target in-service date in the first half of 2024. This IHA application is requesting take that may occur from the pile driving activities in the first year of construction (October 1st, 2020 to September 30th, 2021). Conformance to the ODFW regulatory in-water work window for dredging and in-water impact driving will be implemented to reduce impacts on listed fish species per other permitting authorities. The in-water work window is the period of October 1 to February 15, and the period outside the in-water work window is February 16 to September 30. For this IHA application, the work windows also are used to inform seasonal differences in the population size and density of harbor seals in Coos Bay. The in-water work window also avoids the pupping season for harbor seals. For that purpose, the items shown in Table 2-1 are broken down by the in-water work window and the period outside the in-water work window. In-the-dry and in-water vibratory pile driving may occur year-round at the LNG Terminal.

Some pile-driving activities may be scheduled to occur simultaneously. It is anticipated that only one pile driving rig would be active at any single work location, but pile driving may be occurring at multiple locations. For example, the sheet piling installation at the MOF location may be occurring at the same time the cofferdam sheet piles will be installed at TPP/US-101 location, however these locations are at least a mile apart (Figure 1-1). Concurrent pile driving is not expected to result in an accumulate noise effect on marine mammals.

When the scheduling constraints of the in-water work window is considered, the estimated number of actual days when pile driving would occur is approximately 230 days for the 2020–2021 construction season. For the first year, the periods of activity associated with the pile driving that may result in take of marine mammals are summarized in Table 2-1. None of the temporary piles associated with the Ancillary Activities would be removed during the 2020-2021 construction season.

Table 2-1. Year 1 Piling/Sheet Piling Installation Schedule

Method	Pile Type	In-the-dry vs In-water vs Behind Cofferdam?	Total Piles	Location	Driving Days[a]	Mins Driving per Day
LNG Terminal						
Vibratory	Sheet Pile	In-the-dry	1,246	MOF (outside in water work window)	97	309
Vibratory	Sheet Pile	In-the-dry	623	MOF (inside in water work window)	48	309
Vibratory	Sheet Pile	In-the-dry	113	W. berth wall, 2.5% nearest berm (outside in water work window)	8.5	329
Vibratory	Pipe Pile	In-the-dry	6	TMBB mooring pile (inside in water work window)	10	9
Ancillary Activities (all would occur inside in water work window)						
Impact	Timber	Behind cofferdam	1,150	TPP/US-101 intersection	60	50
Vibratory					60	100

Method	Pile Type	In-the-dry vs In-water vs Behind Cofferdam?	Total Piles	Location	Driving Days[a]	Mins Driving per Day
Vibratory	Sheet Pile	In-water	311	TPP/US-101 intersection	16	100
Impact	Pipe Pile	In-water with BCA (for impact driving)	36	TPP/US-101 intersection	9	20
Vibratory					9	80
Vibratory	Pipe Pile	In-water	33	APCO sites	9	30

Notes:
a. May occur concurrently with other pile-driving activities
TPP/US-101 – TransPacific Parkway/U.S. Highway 101
MOF – Material Offloading Facility
TMBB – Temporary Material Barge Berth
LNG Terminal – Liquid Natural Gas Terminal
BCA – Bubble Curtain Attenuation or equivalent

2.2 Specific Geographic Region

The LNG Terminal site is in Coos County, Oregon, on the bay side of the North Spit of Coos Bay at about CM 7.3, along the existing FNC (Figure 1-1), at the beginning of the confluence between the Jarvis Turn and the Upper Jarvis Range A.

Other project components would include the following:

- The access channel would encompass approximately 22 acres below the HMT elevation of 10.26 feet (NAVD88).
- The proposed marine slip would be just north of the proposed access channel, and west and south of the LNG terminal site. The site currently is upland, and it would be excavated and dredged to a final depth of approximately -45 feet NAVD88.
- The MOF would encompass approximately 3 acres on the southeastern side of the slip.
- The TMBB would be on the shoreline at the southwestern entrance of the slip, where it connects to the access channel. This site would be removed with the excavation of the berm.
- The NRIs of the FNC would be at four locations between the mouth of the Coos Bay estuary and the LNG Terminal site.
- TPP/US-101 would be in the northern reaches of the estuary, near Haynes Inlet and north of APCO sites 1 and 2
- APCO sites 1 and 2 would be east of the Southwest Oregon Regional Airport, across the bay from the LNG Terminal site.
- The Kentuck site would be on the eastern shore of Coos Bay, at the mouth of Kentuck Slough.
- The Eelgrass Mitigation site would be just southwest of the Southwest Oregon Regional Airport.

2.2.1 Physical and Biological Setting

Coos Bay is an inland estuary, meaning that it is a semi-enclosed body of water that empties into the Pacific Ocean. The surface area of Coos Bay covers about 12,380 acres measured at mean high water. The estuary is part of the U.S. Geological Survey (USGS)-designated watershed, Coos Bay (USGS Hydrologic Unit Code [HUC]:17100304). The watershed drains an area of approximately 739 square miles of Oregon's southern coastal range, within the larger South Coast Watershed Basin (ODEQ 2012). Coos Bay is fed by about 30 tributaries, including the Coos River, Millicoma River, Catching Slough, Isthmus Slough, Pony Slough, South Slough, North Slough, Kentuck Slough, and Haynes Inlet.

The Oregon Institute of Marine Biology (OIMB) sampled physical oceanographic data in Coos Bay, near the proposed location of the LNG Terminal access channel, from August 2009 through December 2010 (Shanks et al. 2010, 2011). The OIMB data set included salinity, temperature, and Chlorophyll a. The OIMB data show there is little variation exhibited in salinity during the tidal cycle, but slightly lower salinity levels occur during low tides and slightly higher salinity levels during high tides. In contrast, temperatures are markedly higher during low tides than high tides. In effect, the results of the OIMB sampling program indicate that there is a great amount of seasonal, but only moderate daily, variability in the physical oceanographic data of the waters of Coos Bay near the Jordan Cove LNG Terminal site.

The marine environment along the transit route outside of Coos Bay consists of varied habitats used by aquatic organisms including commercial and recreationally important fish and shellfish, shorebirds and seabirds, and marine mammals. This habitat includes gently sloping nearshore intertidal and subtidal sand area near the Coos Bay mouth and rocky shoreline to the south. Sand and mud flats are the dominant intertidal and subtidal habitat type, but extensive eelgrass beds are also present. Eelgrass mapping surveys conducted between 2005 and 2014 detected more than 1,400 acres of low- and high-density eelgrass communities throughout upper and lower Coos Bay (Ellis Ecological Services 2007 and 2013). Resident and migrant shorebirds congregate on the tidally inundated mudflats along the shore of Coos Bay, to forage on the invertebrates in the shallow waters and exposed mudflats and eelgrass beds, especially during low tides.

Marine fish communities in Coos Bay consist of species found in estuarine and marine waters. Their distribution and abundance vary with physical factors such as bottom conditions, slope, current, salinity, and temperature, as well as season, which can affect migration and spawning timing. As reported by NOAA (Monaco et. al. 1990), some of the more commonly abundant fish include Pacific herring (*Clupea pallasii*), and the non-native American shad (*Alosa sapidissima*). Most fish species are migratory or seasonal, spending only part of their life in these waters. Other common seasonal marine fish species include surfperch (family *Embiotocidae*), lingcod (*Ophiodon elongatus*), rock greenling (*Hexagrammos lagocephalus*), sculpin, surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasii*), English sole (*Parophrys vetulus*), black rockfish (*Sebastes melanops*), northern anchovy (*Engraulis mordax*), eulachon (*Thaleichthys pacificus*), longfin smelt (*Spirinchus thaleichthys*), Pacific tomcod (*Microgadus proximus*), sandsole (*Psettichthys melanostictus*), and topsmelt (*Atherinops affinis*) (Monaco et. al 1990). California halibut (*Paralichthys californicus*) is also present in the bay near Jordan Cove. A few common species like kelp greenling (*Hexagrammos decagrammus*) and starry flounder (*Platichthys stellatus*) reside in the bay year-round.

Clams, crabs, oysters, and shrimp make up important components of these invertebrates in the bay. Some of the most abundant and commercially important of these species include bentnose clams (*Macoma nasuta*), Pacific oyster (*Crassostrea gigas*), Dungeness crab (*Metacarcinus* *magister*), and ghost shrimp (*Neotrypaea californiensis*) (Monaco et. al. 1990). Distribution varies along the route from the LNG Terminal to the bay mouth. Principal subtidal clam beds are found in the lower bay and South Slough although the upper bay also has substantial clamming areas. Clam Island, located at the mouth of Coos Bay, has an abundance of recreationally important clams.

The Coos Bay FNC is included in the Coos Bay Estuary Management Plan (CBEMP) and is zoned Deep-Draft Navigation Channel (37-foot authorized draft). The FNC is bounded by the North Spit on the west and north, and the mainland to the south and east. Along the mainland bounding the FNC are the communities of Charleston and Barview, and the cities of Coos Bay and North Bend. The Coos Bay FNC extends from the mouth of Coos Bay to the city of Coos Bay docks at about Channel Mile (CM) 15.1. The entrance to Coos Bay is located between two jetties that are about 640 meters apart and that extend about 915 meters from the shore. There is a bar at the Coos Bay entrance, which establishes the minimum draft of the FNC. The channel width at the entrance mark is approximately 460 meters, reducing to approximately 210 meters at CM 0. From CM 1 to the LNG Terminal (at about CM 7.5) the authorized channel width is 300 feet.

2.2.2 Development and Vessel Traffic in Coos Bay

The estuary of Coos Bay contains a mixture of undeveloped and developed shoreline. Generally speaking, the western shoreline formed by the sand spit barrier island which is largely undeveloped, and the triangular piece of land formed by the two main arms is largely developed, including the regional airport, residential development, and industrial development (Figure 1-1).

The Port of Coos Bay is the busiest seaport in Oregon and offers diverse facilities and infrastructure to support the regional economy, including commercial vessel shipping and a large commercial fishing fleet based at the Charleston Marina, and a U.S. Coast Guard installation (Port of Coos Bay 2015). The Charleston Marina provides moorage for approximately 165 to 200 commercial fishing boats and has approximately 250 recreational boat slips. Several marine terminals and docks are located along the length of the federal navigation channel, beginning near channel mile 5 and extending to multiple terminals/docks at channel mile 15. The majority of these terminals handle forest products, but others handle petroleum products, ores, and other raw materials as well as finished goods (Port of Coos Bay 2015). There were 100 vessel calls in 2017, transmitting a total of 2 million tons of material (Port of Coos Bay 2018).

Channel depth is maintained at -37 feet MLLW for the length of the 15.2-mile FNC. As described in Section 1.4.1, the FNC is regularly dredged in order to maintain proper depths. In addition to the FNC, dredging of marina facilities occurs intermittently throughout the bay.

3. Species and Numbers of Marine Mammals

"The species and numbers of marine mammals likely to be found within the activity area."
(50 CFR Section 216.104[a][3])

A marine mammal population stock is the fundamental unit of legally mandated conservation efforts in the MMPA. Biologically, a stock is a group of animals in common spatial arrangement that interbreeds (Barlow et al. 1995). The MMPA requires NMFS and the U.S. Fish and Wildlife Service to prepare assessment reports for each stock of marine mammal occurring in waters under the jurisdiction of the United States. Stock assessments include a description of the stock's geographic range, a minimum population estimate, current population trends, current and maximum net productivity rates, optimum sustainable population levels and allowable removal levels, and estimates of annual human-caused mortality and serious injury through interactions with commercial fisheries and subsistence hunters.

3.1 Species Present

The Project study area for this IHA application is the Coos Bay estuary, from the mouth of the estuary to roughly 1 mile past the LNG Terminal site, at the US-101 bridge (see Figure 1-1), and also includes the areas around the Ancillary Activities—the APCO sites, TPP/US-101 intersection, Kentuck sites, and the Eelgrass Mitigation site. Because of the curvature of the estuary and the location of project activities in relation to the mouth of the estuary, underwater noise generated by project activities would not extend out into the Pacific Ocean.

3.1.1 Background and Literature Review

To ascertain what species of marine mammals may occur in Coos Bay, a variety of technical resources and news articles were reviewed. Officials with the Coos Bay office of the U.S. Bureau of Land Management (BLM 2006) identified three species of pinnipeds that occur on the Coos Bay North Spit and in the Coos Bay estuary study area: Pacific harbor seal (*Phoca vitulina*), Steller sea lion (*Eumetopias jubatus*), and California sea lion (*Zalophus californianus*). They reported that harbor seal and California sea lion forage in Coos Bay throughout the year and use dredge material islands as haul-out sites. Although northern elephant seals (*Mirounga angustirostris* – California Breeding Stock) have not been recorded in Coos Bay, they regularly haul-out at Cape Arago, just south of the mouth of Coos Bay (ODFW 2018a), and it is reasonable to expect that they occasionally enter Coos Bay. Similarly, small groups of harbor porpoise are common in the nearshore waters of the Oregon coast, and although records could not be located, it is reasonable to expect that they may occasionally enter Coos Bay.

The Seattle Times (2007) reported that five killer whales (*Orcinus orca*–transient population) entered and exited Coos Bay in June 2007. The group was identified as transient stock. A radio-tagged, single adult male killer whale, a member of the Eastern North Pacific Southern Resident Stock, was tracked off the Coos Bay coast in January 2013, reported by the Coos Bay World (2013). The individual's movements had been tracked along the West Coast continental shelf after it left Puget Sound, but it was not reported to have entered the Coos Bay estuary (NMFS 2013).

Similarly, the Corvallis Gazette–Times (2000) reported that a gray whale (*Eschrichtius robustus*) entered Coos Bay and traveled 15 miles from the mouth into the estuary in June 2000. Furthermore, a local television station (KCBY, North Bend) reported a gray whale occurrence in Coos Bay in November 2009, although this has not been verified. The November 2009 observation likely occurred during the gray whale's southbound migration, while the observation in June 2000 probably was during the northbound migration, both of which occur in near-shore waters off the coast of Oregon.

Pacific harbor seals (harbor seal) have been reported for decades to occur in Coos Bay. Pearson (1969) reported 35 harbor seals present in Coos Bay (apparently at the Pigeon Point haul-out) during May and June 1968. Steller sea lions were observed at Simpson Reef, south of Cape Arago, but no other pinniped species were reported in Coos Bay (Pearson 1969). Graybill (1981) reported peak numbers of harbor seals at two haul-outs in Coos Bay, on each side of the FNC (Pidgeon Point and the eastern shore of the North Spit [Clam Island]). No other pinnipeds, including northern elephant seal, California sea lion, and Steller sea lion, were reported in Coos Bay by Graybill (1981). However, these species often haul-out at Cape Arago (ODFW 2018a), 3.7 miles south of the mouth of Coos Bay, and thus occasionally may enter Coos Bay. Coos Bay has been reported as an important harbor seal pup production area along the Oregon coast (Brown 1988).

JCEP is aware of no systematically collected records of cetacean occurrences in the Coos Bay estuary.

3.1.2 Field Surveys

In support of this IHA application, JCEP authorized AECOM Technical Services (AECOM) to conduct two surveys of marine mammals in Coos Bay to verify the information collected in the available literature. In May 2017, AECOM undertook a 4-day field survey of the study area, between the entrance to Coos Bay to the US-101 bridge, with the objective of documenting marine mammal use of the study area. The team surveyed 42 transect lines, covering 111.5 nautical miles (nm) of planned transects (on-effort), and conducted an additional off-effort survey of 60.7 nm, for an overall total of 172 nm of surveys in the study area. The off-effort surveys were observations that were collected when transiting between transect lines, and when relevant activities occurred away from the current transect line, such as taking photographs, recording ambient sounds, and observing behaviors. The surveys were conducted during optimal conditions (Beaufort Scale, 0 to 3) by two experienced marine mammal observers. To begin to understand the ambient acoustic environment in Coos Bay, hourly in-water acoustic measurements were collected for up to 10 minutes at various sites during the surveys. This survey was timed to coincide with the pupping season for harbor seals, when that species has the greatest abundance in the estuary. The full results of this survey are provided in Appendix A.

During the May 2017 survey, three species of marine mammals in the Coos Bay estuary were identified during the transect (on-effort) surveys: harbor seal, California sea lion, and Steller sea lion, with harbor seal being the most commonly surveyed species. All three species, plus a pair of killer whales, were observed during the off-effort surveys. The killer whales were observed engaging in a predation event east of the project site. Based on the size of the individuals and characteristics of the feeding activity, the researchers inferred that the killer whales were from the transient stock and had preyed on a seal.

In November and December 2018, AECOM completed another field survey, again to gather information on the occurrences of marine mammals in the project area during the ODFW regulated in-water work window. Based on previous reports (Graybill 1981), harbor seal populations in the estuary were expected to be lower in the late fall and winter months. The survey was conducted by the same two marine mammal observers who conducted the May 2017 survey. During the November 2018 survey, the team surveyed a total of 50 transect lines, over 28.1 nm (52 kilometers). Surveys were conducted throughout the daylight hours, unless limited by unsuitable weather conditions, which included high winds, heavy rain, and sea states greater than Beaufort 3. In addition to conducting the vessel-based surveys, AECOM contracted for drone overflights of the Clam Island and Pigeon Point haul-out sites. The flights collected aerial photography of the haul-out sites and adjacent areas, and the photos were used to count the harbor seals hauled out. Harbor seals were the only marine mammal observed in the estuary during the fall surveys (see Appendix A).

As a component of the surveys, AECOM collected references and interviewed local marine biologists about cetaceans entering the estuary, including killer whales, gray whales, humpback whales (*Megaptera novaeangliae*), and harbor porpoises. Elephant seals, Steller sea lions, gray whales, humpback whales, and harbor porpoises were described as using the waters within a few miles of shore, and on rare occasions coming into the waters of the lower estuary.

3.2 Species Abundance

Stock estimates of the seven marine mammals with a potential to enter the Coos Bay estuary are shown in Table 3-1. These stock estimates are for the identified regions on the Pacific Coast out to the end of the exclusive economic zone (EEZ). Stocks of smaller populations, as represented near or in Coos Bay, would be substantially lower. Only harbor seals, California sea lions, and Steller sea lions are expected to be regular visitors, with the harbor seals most likely to be present throughout the year in the Project study area and near the project site. Transient killer whales are likely infrequent visitors to the estuary waters.   In addition, because of the potential occurrence, however rare, of harbor porpoise and gray whales entering Coos Bay, take is being requested of these species as well. Northern elephant seals have been noted to occur outside Coos Bay (BLM 2006), and the ODFW has noted that the species haul out year-round at Cape Arago (ODFW 2018a), and thus the potential exists for an animal to enter the estuary throughout the year, though given their deep-water habitat preference the likelihood of occurrence is very low.

Based on the humpback whale’s listing under the ESA and its status under the MMPA as depleted stock, take is not being requested to avoid behaviorally disturbing this species, and no further analysis is needed for this species. In the extremely unlikely event that a humpback whale(s) would enter the estuary during pile driving, pile driving would cease either until the whale(s) left or emergency consultation with NMFS can be completed.

Table 3-1. Marine Mammal Species, Stocks, and Abundance Estimates

Common Name, (*Scientific Name*)	MMPA Stock in Activity Area	Total Population Estimate	Minimum Population Estimate	SAR Last Revised	Population Trend
Pacific harbor seal (*Phoca vitulina*)	Oregon and Washington Coast Stock[b]	16,165	Unknown[c]	2014	Likely Stable[c]
Northern elephant sea (*Mirounga angustirostris*)	California Breeding Stock	179,000	81,368	2014	Increasing
California sea lion (*Zalophus californianus*)	U.S. Stock[b]	296,750	153,337	2015	Increasing
Steller sea lion (*Eumetopias jubatus*)	Eastern U.S. Stock[a]	52,139	41,638	2016	Increasing

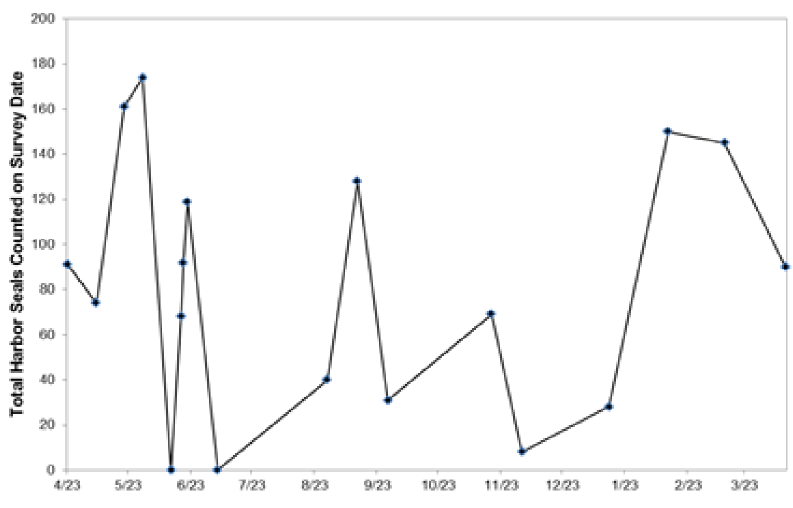
Common Name, (*Scientific Name*)	MMPA Stock in Activity Area	Total Population Estimate	Minimum Population Estimate	SAR Last Revised	Population Trend
Gray whale (*Eschrichtius robustus*)	Eastern North Pacific Stock (including Pacific Coast Feeding Group)[b]	20,990	20,125	2015	Stable
Killer whale (*Orcinus orca*)	Transient Stock[a]	243	243	2013	Unknown
Harbor porpoise (*Phocoena phocoena*)	Northern California/ Southern Oregon Stock[b]	35,769	23,749	2014	Likely Stable

Notes:

a. Species' stock reports included in Alaska Marine Mammal Stock Assessments, 2016 (Muto et al. 2017).
b. Species' stock reports included in the U.S. Pacific Marine Mammal Stock Assessments, 2016 (Carretta et al. 2017).
c. Most recent population estimates are more than 8 years old (1999); therefore, NMFS opted to not provide minimum population or potential biological removal estimates in the most recent stock assessment (Carretta et al. 2017).

SAR = Stock Assessment Reports

Based on the results of the literature review and AECOM's surveys, harbor seals are expected to be regularly present in the Project study area. This expectation is supported by observations made between April 1980 and March 1981 (Graybill 1981). Parturition in the Coos Bay estuary has been noted to commence in late April and peak in May; very young pups were observed at both haul-out sites (Graybill 1981). In 1980-1981, harbor seal abundance in the estuary increased steadily from April through July, and then gradually declined from late summer through winter (Graybill 1981). However, aerial surveys of Coos Bay harbor seal haul-outs that were conducted between April 1984 and April 1985 (Brown 1988) indicated seal abundance from one survey date to another was highly variable (Figure 3-1), though the peak in May (which included adults with pups) was consistent.



Source: Brown 1988

Figure 3-1. Harbor Seals Counted in Coos Bay during Aerial Surveys from April 1984 to April 1985

As noted above, occurrences of killer whale, gray whale, and harbor porpoise in the Coos Bay estuary study area are infrequent and unpredictable.

4. Affected Species Status and Distribution

"A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities." (50 CFR Section 216.104[a][4])

Temporary effects on marine mammals from construction activities are expected to occur only in the Coos Bay estuary. The following discussion focuses on the species potentially affected by construction of the LNG Terminal and Ancillary Activities, which would be limited to those species with a reasonable likelihood of occurring in the Coos Bay estuary at some point over the multi-year construction period. Those species would include:

- Pacific harbor seal (*Phoca vitulina*)
- Northern elephant seal (*Mirounga angustirostris*)
- California sea lion (*Zalophus californianus*)
- Steller sea lion (*Eumetopias jubatus*, Eastern Distinct Population Segment [DPS])
- Gray whale (*Eschrichtius robustus,* Eastern North Pacific DPS)
- Killer whale (*Orcinus orca*–transient population)
- Harbor porpoise (*Phocoena phocoena*)

4.1 Pacific Harbor Seal

Strategic stocks are those for whom human-caused mortality is likely to be significant relative to stock size, greater than the annual population production increment (Barlow et al. 1995). The Oregon and Washington Coast stock of harbor seals is designated as non-strategic (Barlow et al. 1995). Human-caused mortality relative to commercial fisheries is unknown but is considered to be small relative to the stock size, based on fishery observer and stranding data (Jefferies et al. 2003; Brown et al. 2005).

Harbor seal has the broadest range of any pinniped, inhabiting both the Atlantic and Pacific Oceans. In the Pacific, it is found in near-shore coastal and estuarine habitats from Baja California to Alaska, and from Russia to Japan. The Pacific harbor seal is a non-migratory species, with a wide range in movement patterns recorded (Zier and Gaydos 2014). Three recognized populations of Pacific harbor seal are found along the West Coast of the continental United States: the California stock, which occurs in California coastal waters; the Washington inland waters stock, which occurs in Hood Canal, Puget Sound, and the Strait of Juan de Fuca out to Cape Flattery; and the Oregon/Washington Coastal stock. Although the different populations are genetically distinct, the geographical boundary between the Oregon/Washington Coastal stock and the California stock is determined by the boundary between Oregon and California. The estimated population of the Oregon/Washington stock is 16,165 (Table 3-1). The current population assessments are extrapolated from observations of the number of Pacific harbor seals ashore during the peak haul-out period (May to July). The number of Pacific harbor seals observed was multiplied by a correction that is equal to the "inverse of the estimated fraction of seals on land" (NMFS 2017a). Pacific harbor seal is precocial, with pups able to enter the water after about an hour from birth. Thus, it is not possible to count the number of pups. The harbor seal is not listed as threatened or endangered per the ESA.

Harbor seals are the only pinniped species documented to occur regularly in the Coos Bay estuary area in large numbers. The ODFW counted harbor seals with pups at three of four haul-out sites in Coos Bay in May and June overflights in both 2003 (Wright 2013) and 2014 (NMFS 2019). The results of these surveys are presented in Table 4-1. Two of the sites, Pigeon Point and North Spit (Clam Island), also were noted as being used during parturition in 1980–1981 (Graybill 1981). Harbor seals were counted during the same periods at two sites—Cape Arago (located 3.7 miles south of the mouth of Coos Bay) and in Coos Bay—with nearly twice the number of harbor seals and pups occurring outside the estuary compared to within the estuary. This trend was also noted by Wilson (1993). There is also a documented seasonal variation in the numbers of hauled out seals along the Oregon coast, with increased observed in the spring and summer months (Wilson 1993).

Table 4-1. Harbor Seal Occurrences at Haul-Out Sites in the Coos Bay Estuary, 2003 and 2014 Surveys

Haul-Out Site	May		June	
	Total	**Pups**	**Total**	**Pups**
2003 Survey				
Clam Island	306	83	293	50
Coos Port	0	0	36	5
Pigeon Point	4	0	8	1
South Slough	14	0	6	0
Total	**324**	**83**	**343**	**56**
2014 Survey				
Clam Island	287	87	214	40
Coos Port	48	7	75	14
Pigeon Point	17	6	0	0
South Slough	n/a (fog)	n/a (fog)	44	8
Total	**352**	**100**	**333**	**62**

Source: Wright 2013, NMFS 2019

There are four established harbor seal haul-out sites within the Coos Bay estuary (Figure 4-1):

- Clam Island, consisting of exposed elongated sand bars and mud flats of undetermined length on the western side of the FNC (identified as the North Spit haul-out by Graybill [1981]);
- Coos Port, between North Bend and the city of Coos Bay, on the eastern side of the three islands east of the main channel.
- Pigeon Point, on the eastern side of the FNC, south of Empire;
- South Slough, by Charleston, approximately 0.75 mile south of the Cape Arago Highway; and

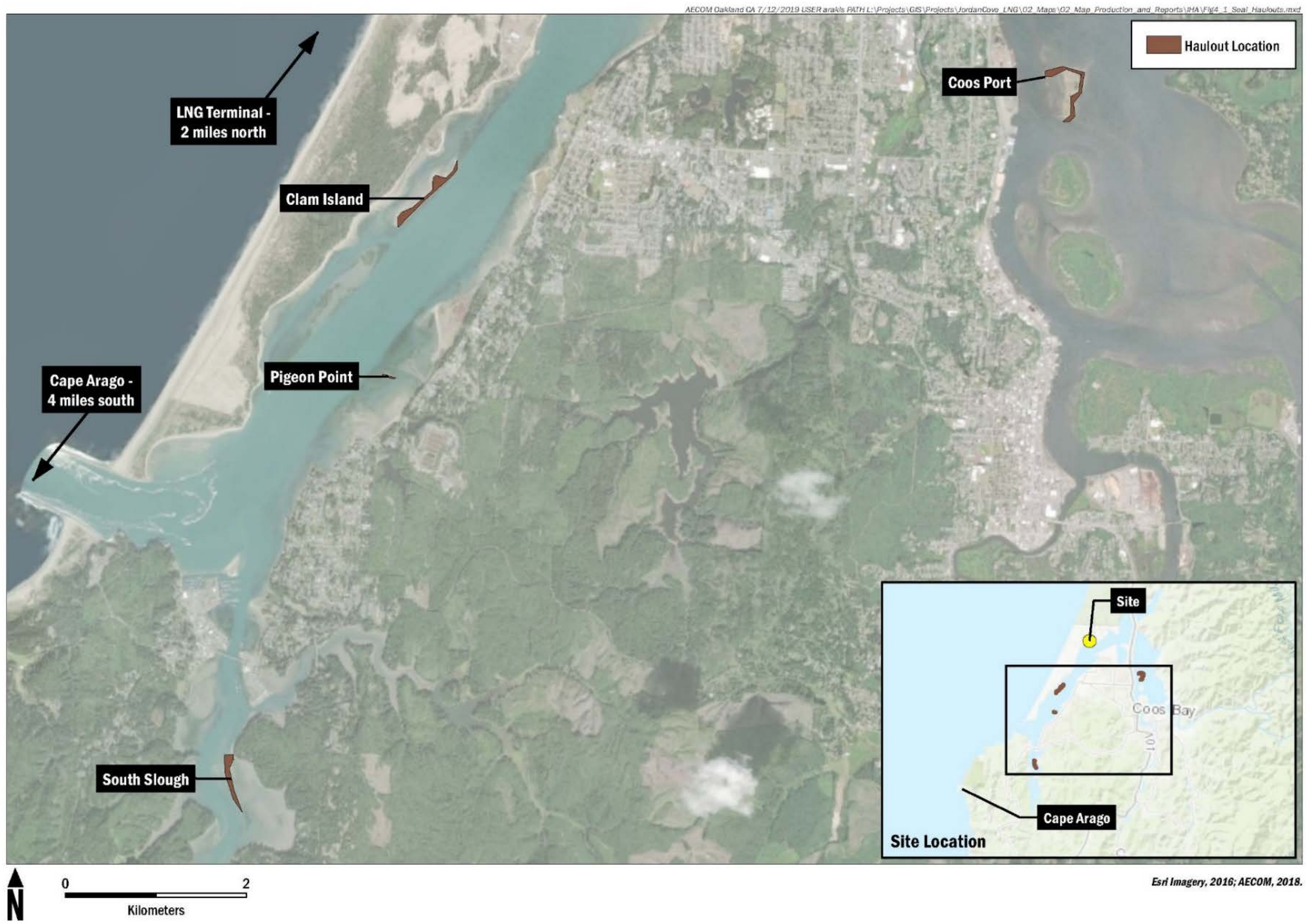


Figure 4-1. Harbor Seal Haul-Out Areas in Coos Bay Estuary

The Clam Island and Pigeon Point haul-outs flank each side of the FNC. The closest haul-out to the LNG Terminal site occurs at the northern end of Clam Island, approximately 3 miles from the project site. Some of the ancillary features are closer, such as the NRIs, which are about 0.5 to 1 mile from Clam Island. There are no established haul-outs in the Coos Bay estuary for the other three pinniped species that could differentially occur in the area: northern elephant seal, California sea lion, and Steller sea lion. However, the U.S. Bureau of Land Management (BLM 2006) reported that as with harbor seals, California sea lions forage in Coos Bay throughout the year, and occasionally use dredged materials islands as haul-out sites.

Similarly, Wright (2016) noted that harbor seals forage throughout Coos Bay, and thus they could be expected to occur anywhere in the estuary. It is reasonable to assume that they would show varying local concentrations that would correspond to local fish abundances throughout the year.

Over the last several decades, intermittent and independent surveys of harbor seal haul outs in Coos Bay have been conducted. The most recent aerial survey of haul-outs occurred in 2014, the results of which are summarized in Table 4-1. Those surveys were conducted during a time when the highest number of animals would be expected to haul out (i.e., the latter portion of the pupping season [May and June] and at low tide). Based on logistic population growth models, harbor seal populations of the Oregon Coast had reached carrying capacities during the late 1980s and early 1990s (Brown et al. 2005). Using these data, an estimation of the number of seals using the Coos Bay estuary haul-outs can be made by simply dividing the area of the Coos Bay estuary by the estimated population size. NMFS considers the Oregon/Washington Coast stock of harbor seal to be stable (Carretta et al. 2017), and thus for this IHA application, JCEP assumed the number of harbor seals in Coos Bay to be equivalent to that reported in 2003.

As described in Section 2.1, the ODFW in-water work window is the period of October 1 to February 15, and the period outside the ODFW in-water work window is February 16 to September 30. These periods serve well to distinguish between the periods of lower and higher harbor seal presence expected during the fall and winter months versus the spring/summer period when pupping occurs.

The Coos Bay estuary has an area of 55.28 square kilometers, as measured using geographic information system (GIS) files available from the Coastal Atlas (2018). Since the surveys conducted by AECOM in May 2017 did not include haul-out surveys, the 2014 data is considered the best available. The May and June 2014 haul-out survey data provides a maximum of 352 and 333 harbor seals, respectively, in Coos Bay during the pupping season. The average of these two values of 342.5 is used for estimating the in-water density of harbor seals in Coos Bay, which provides 342.5/55.28 = 6.2 animals per square kilometer. Thus, a density of 6.2 animals per square kilometer is used in this take estimate for outside the in-water work period of February 16 to September 30.

AECOM conducted further surveys during November and December 2018 to determine a fall/winter estimate for harbor seals outside the spring and summer. This survey resembled the 2003 surveys by Wright (2013) because it included 3 days of aerial (drone) flyovers at the Clam Island and Pigeon Point haul-outs to capture aerial imagery. In addition, vessel-based transect surveys over a 3-day period, using the same survey methods as in May 2017. This field effort observed a maximum of 167 harbor seals hauled out at the Clam Island and Pigeon Point sites on any one day. In addition, the line transect surveys had a lower harbor seal sighting rate at 0.12 seal per kilometer, as compared to the May observed rate of 6.2 seals per kilometer. Using this information, the population estimate used in this take estimate for the in-water work period of October 1 to February 15 is established as 167/55.28 = 3.0 animals per square kilometer.

Harbor seals generally foraging with in close proximity to their haul-outs. For example, a study of radio tagged harbor seals in San Francisco Bay found that the majority of foraging trips were less than 10 km from their regular haul-out (Grigg et al. 2012), and a similar study in Humboldt Bay found that the majority of seals travelled 13 km or less to forage (Ougzin 2013). Both studies found that harbors seals typically forage at in relatively shallow water depths; a median value of 7 m was reported for the San Francisco Bay Study (Grigg et al. 2012).

4.2 Northern Elephant Seal

Northern elephant seal in the non-strategic California Breeding stock regularly occur at haul-out sites on Cape Arago, approximately 3.7 miles south of the entrance to Coos Bay. Although northern elephant seal ranges as far north as Alaska and as far south as Mexico, breeding locations are limited to the coast of Central California, the Channel Islands off California, and Baja California in Mexico (Lowry et al. 2014). Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, and females feed further south, in the offshore waters of Washington and Oregon. Adults return to land between March and August to molt, with males returning later than females (NMFS 2015). Adults return to their feeding areas again between the spring/summer molt and the winter breeding season. The Northern elephant seal population size is estimated by approximation from the number of pups produced, because all age classes are not ashore simultaneously. Based on counts of elephant seals at U.S. rookeries in 2010, Lowry et al. (2014) reported that 40,684 pups were born. From this, a total population estimate of approximately 179,000 elephant seals has been made (Lowry et al. 2014), of which approximately 81,000 are the California Breeding stock (NMFS 2015). The California Breeding stock of elephant seal is not listed as threatened or endangered per the ESA.

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 (Brent et.al. 1995). Pup mortality is high when they make the first trip to sea in May, and this period correlates with the time of the most strandings. Pups of the year return in the late summer and fall to haul out at rookery sites, but occasionally may make brief stops in Coos Bay. Scordino (2006) reported total counts (average, maximum, minimum) of harbor seal, elephant seal, California sea lion, and Steller sea lion at Cape Arago during each month surveyed between 2002 and 2005 (Figure 4-2). Abundance of elephant seals was low in all months, with a maximum of 54 animals reported in May (Scordino 2006).

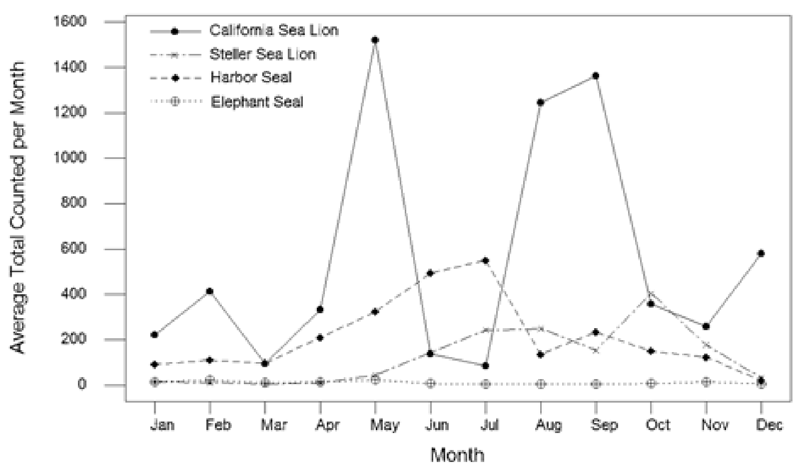
4.3 California Sea Lion

California sea lion in the non-strategic U.S. Stock regularly occurs at haul-out sites on Cape Arago, approximately 3.7 miles south of the entrance to Coos Bay. Based on genetic variations in the mitochondrial DNA, five genetically distinct populations of California sea lions exist: Pacific temperate, Pacific subtropical, Southern Gulf of California, Central Gulf of California, and the Northern Gulf of California. Members of the Pacific temperate population, which range between Canada and Baja California, occur in the project area. This population is estimated to be around 296,750 individuals (Table 3-1) and is not listed as threatened or endangered. Because different age and sex classes are not all ashore at any given time, the population assessment is based on an estimate of the number of births and number of pups in relation to the known population. The current population estimate is derived from visual surveys, conducted in 2007, of the different age and sex classes observed ashore at the primary rookeries and haul-out sites in southern and central California, coupled with an assessment done in 2008 of the number of pups born in the Southern California rookeries (NMFS 2017a). Estimates of the total population size based on the more recent pup counts made in 2011, which show the highest record to date, currently are being developed.

Statistical analysis of the pup counts between 1975 and 2010 determined an approximate 5.4 percent annual increase of the California stock. However, this did not take into account decreases associated with El Niño years, observed in 1983, 1984, 1992, 1993, and 2003. During these periods, pup counts decreased by between 20 and 64 percent (NMFS 2017a). Although pup counts reached pre-El Niño levels within 2 years of the 1992-1993, 1997-1998, and 2003 El Niño events, it took 5 years after the 1983-1984 El Niño event for pup production to reach pre-1982 levels. According to the National Oceanic and Atmospheric Administration (NOAA), one of the reasons for this fluctuation could be that during El Niño events, an increase occurs in pup and juvenile mortality, which in turn affects future age and sex classes. In addition, because fewer females are present in the population after such events, pup production is further limited. The decline in pup production observed during 2000 and 2003 can be attributed in part to previous El Niño events, which affected the number of reproductive females in the population; and in part to domoic acid poisoning and an infestation of hookworms, which caused an increase in pup mortality (NMFS 2017a).

The occurrence of the California sea lion along the Oregon coast is seasonal. The primary areas where it comes ashore are Cascade Head, Tillamook County; Cape Argo, Coos County; and Rouge Reef and Orford Reef in Curry County (ODFW 2018b).

Scordino (2006) reported total counts (average, maximum, minimum) of harbor seal, elephant seal, California sea lion, and Steller sea lion at Cape Arago during each month surveyed between 2002 and 2005. California sea lion was the most numerous pinniped for most of the year, with numbers increasing during May, August, and September (Figure 4-2).



Source: Scordino 2006

Figure 4-2. Total Monthly Counts of Four Pinniped Species at Cape Arago, Averaged for All Observations from 2002 to 2005

4.4 Steller Sea Lion

The Steller sea lion was divided into two DPSs, based on geographic location and genetic differentiation (NMFS 2008). The Western DPS breeds in Alaska, west of the 144-degree mark, and Asia; whereas the Eastern DPS breeds from southeastern Alaska to California (AFSC 2010). The Steller sea lion Western DPS was listed as federally threatened in 1990. The Eastern DPS was delisted because of recovery in 2013 (NMFS 2014). NMFS still considers the Steller sea lion Eastern DPS as strategic. The Eastern DPS is the species stock that would occur in Coos Bay.

The females give birth between May and July and will breed soon thereafter (NMFS 2008). Steller sea lions use rookeries and haul-outs during this breeding season, which are found throughout their geographic range. These terrestrial habitats are chosen based on various factors, including wind exposure, substrate, human disturbance, and prey availability. Generally, rookeries occur on remote islands, reefs, rocks, or beaches with minimal predation. These sites range from the Kuril Islands, the Aleutian Islands, and Prince William Sound, Alaska, to Año Nuevo Island, California. Haul-outs are used for rest in the non-breeding season and the breeding season. Pelagic habitat for the Steller sea lion has not been well-studied, despite Steller sea lions spending the majority of their lives at sea. During the summer, foraging trips are shorter in duration, and they do not travel as far from breeding grounds; whereas in the winter, they can travel far from their rookeries and haul-out sites. (58 Federal Register [FR] 45269, August 27, 1993)

The Eastern DPS has rookeries in California at Año Nuevo Island, the Southeast Farallon Islands, Sugarloaf Island, and Cape Mendocino (58 FR 45269). Oregon is home to the largest breeding site in U.S. waters south of Alaska, with breeding areas at Three Arch Rocks (Oceanside), Orford Reef (Port Orford), and Rogue Reef (Gold Beach) (ODFW 2018a). In surveys along the Oregon Coast, Steller sea lion was observed ashore at 10 sites, extending from the South Jetty at the mouth of the Columbia River in Clatsop County, south to Rogue Reef in Curry County (ODFW 2018b).

ODFW reported total counts of Steller sea lion (no pups) at Shell Island and Simpsons Reef at Cape Arago between 2003 and 2013, but none was counted in the Coos Bay estuary (Wright 2013). Scordino (2006) reported total counts (average, maximum, minimum) of harbor seal, elephant seal, California sea lion, and Steller sea lion at Cape Arago during each month surveyed between 2002 and 2005. Steller sea lion numbers generally increased from May through October and declined during winter months (Figure 4-2).

4.5 Gray Whale

Although gray whales once were found in three populations across the globe, the Atlantic population is believed to be extinct, and the species is now limited to the Pacific Ocean, where it is divided into eastern and western stocks. Eastern North Pacific gray whales migrate each year along the west coast of North America, while Western North Pacific gray whales primarily migrate along the east coast of Asia to Japan and are listed as endangered under the ESA. It is the Eastern North Pacific stock that may occur in Coos Bay. Based on shore observations in 2006 and 2007, the population of Eastern North Pacific gray whales was estimated to consist of 20,990 individuals (Table 3-1). With the exception of an unusual mortality event in 1999 and 2000, the population of this gray whale stock has increased over the last 20 years (Carretta et al. 2017). Gray whales undertake annual migrations from northern feeding waters, primarily in the Bering, Chukchi, and western Beaufort seas during the summer, before heading south to breeding and calving grounds off Mexico over the winter. Between December and January, late-stage pregnant females, adult males, and immature females and males migrate southward. The northward migration occurs in two stages between February and late May. The first group, consisting of adult males and immature females, moves north in this stage, while females with calves spend more time in southern waters and travel north later (Calambokidis et al. 2014). A few individuals may enter large estuaries, including Coos Bay, during their northward migration.

4.6 Killer Whale

Based on data regarding association patterns, acoustics, movements, genetic differences, and potential fishery interactions, eight killer whale stocks are recognized in the Pacific U.S. EEZ (NMFS 2013), with three relevant to the Oregon coast: 1) the Eastern North Pacific Southern Resident stock—occurring from Alaska to California, with a summer preference for the inland waters of Washington and southern British Columbia (winter preferences are not defined), listed as endangered under the ESA in November 18, 2005 (NMFS 2005); 2) the Eastern North Pacific Transient stock (or transient stock)—occurring from Alaska to California (unlisted); and 3) the Eastern North Pacific Offshore stock—occurring from Southeast Alaska through California (unlisted) (NMFS 2000).

Some killer whales in the Eastern North Pacific Southern Resident stock have been observed offshore of Oregon during seasonal movements (NMFS 2005) but have not been sighted in Coos Bay. Differences in coloration and dorsal fin shape make it possible for experienced observers to tell the difference between resident and transient killer whales. Members of this stock feed on fish, mainly salmon, while killer whales in the transient stock feed on pinnipeds and small cetaceans (NMFS 2005). The transient stock has been documented as occurring in Coos Bay, including AECOM's observation of a pair of killer whales feeding on what was concluded to be a seal during the 2017 field survey. Overall, the size of this stock is poorly understood, and the minimum population estimate for the Eastern North Pacific Transient stock of 243 animals is considered conservative (Muto et al. 2017) (Table 3-1).

4.7 Harbor Porpoise

Harbor porpoise has a broad range in both the Atlantic and Pacific oceans. In the Pacific, they are found from Point Conception, California to Alaska; and from Kamchatka to Japan. The harbor porpoise population along the Pacific coastline consists of nine distinct stocks (i.e., the Morro Bay, Monterey Bay, San Francisco-Russian River, northern California/southern Oregon, northern Oregon/Washington coast, Inland Washington, Southeast Alaska, Gulf of Alaska, and Bering Sea stocks). The northern California/Southern Oregon stock is the population that could occur in the project area. This stock consists of an estimated 35,800 individuals, based on aerial surveys that were conducted between 2007 and 2011 (Table 3-1). The northern California/Southern Oregon stock is not listed as threatened or endangered under the ESA. No harbor porpoise was observed during the 2017 and 2018 surveys conducted by AECOM. A stranded baby harbor porpoise was rescued by BLM rangers in 2015 at the North Spit (KVAL 2015). Older observations indicate that harbor porpoises are not rare inside Coos Bay estuary within 6 km of its mouth (Bayer 1985).

During the AECOM field efforts in 2017 and 2018, harbor porpoise was not observed however, the supplementary local information collected during the 2017 interviews indicated that harbor porpoise do enter the lower estuary on occasion – particularly when herring or other forage fish were in abundance (Appendix A).

5. Type of Incidental Taking Authorization Requested

"The type of incidental taking authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury and/or death) and the method of incidental taking." (50 CFR Section 216.104[a][5])

JCEP is requesting the issuance of an IHA pursuant to Section 101(a)(5) of the MMPA for Level B harassment of harbor seal, California sea lion, northern elephant seal, harbor porpoise, Steller sea lion, gray whale, and transient killer whales during construction of the LNG Terminal and Ancillary Activities. Underwater noise generated during the pile-driving activities described in Section 1 may have the potential to take marine mammals, as defined by the MMPA. This section describes the applicable noise thresholds and presents an analysis to estimate the distances over which those thresholds may be exceeded.

5.1 Applicable Thresholds for Take

In 2010, NMFS established interim thresholds regarding the exposure of marine mammals to high-intensity noise that may be considered take under the MMPA. Updated NOAA guidance on assessing the effects of underwater noise on marine mammals for agency impact analysis was adopted in 2016 (NMFS 2016), and minor updates were provided in 2018 (NMFS 2018). The updated guidance included sound thresholds for slight injury to an animal's hearing, or permanent threshold shift (PTS) (Level A harassment). The underwater sound pressure threshold for slight injury or PTS (Level A harassment) is a dual-metric criterion for impulse noise (e.g., impact pile-driving), including both a peak pressure and cumulative sound exposure (cSEL) threshold, which is specific to the species' hearing group (i.e., phocids [i.e., harbor seal and northern elephant seal], otariids [i.e., California sea lion and Steller sea lion], low-frequency cetacean [i.e., gray whale], mid-frequency cetacean [i.e., killer whale], and high-frequency cetacean [i.e., harbor porpoise]). For continuous noise (e.g., vibratory pile extraction or driving), the PTS threshold is based on cSEL for each species hearing group. These Level A thresholds are summarized in Table 5-1.

For continuous noise, root mean square (RMS) levels are based on a time constant of 10 seconds, and those RMS levels are averaged across the entire event. For impact pile driving, the overall RMS level is characterized by integrating sound energy for each acoustic pulse across 90 percent of the acoustic energy in each pulse and averaging all the RMS levels for all pulses.

The application of the standard 120 decibels (dB) RMS threshold for underwater continuous noise sometimes can be problematic because this threshold level can be either at or below the ambient noise level of certain locations, and not all species may respond to noise at that level. Exposure thresholds for continuous noise have been developed based on the best available scientific information on the response of gray whales to underwater noise. To date, very little research has been conducted with little data supporting a response by pinnipeds or odontocetes to continuous noise from vibratory pile driving as low as the 120 dB threshold. Southall et al. (2007) summarized numerous behavioral observations made of low-frequency cetaceans to a range of non-pulse noise sources, such as vibratory pile driving. Generally, the data suggest no or limited responses to received levels of 90 to 120 dB RMS, and an increasing probability of behavioral effects in the 120 to 160 dB RMS range.

Table 5-1. Injury and Behavioral Disruption Thresholds for Airborne and Underwater Noise

Hearing Group and Species Considered	Airborne Threshold (Impact and Vibratory Pile-Driving)	Underwater Continuous Noise Thresholds (e.g., Vibratory Pile-Driving)		Underwater Impulse Noise Thresholds (e.g., Impact Pile-Driving)		
	Level B RMS Threshold[a]	Level A cSEL Threshold	Level B RMS Threshold	Level A Peak Threshold[b]	Level A cSEL Threshold[b]	Level B RMS Threshold
Phocids (Pacific harbor seals, northern elephant seals)	90 dB (unweighted)	201 dB	120 dB	218 dB	185 dB	160 dB
Otariids (California sea lions, Steller sea lions)	100 dB (unweighted)	219 dB	120 dB	232 dB	203 dB	160 dB
Low-Frequency Cetaceans (gray whales)	N/A	199 dB	120 dB	219 dB	183 dB	160 dB
Mid-Frequency Cetaceans (killer whales)	N/A	198 dB	120 dB	230 dB	185 dB	160 dB
High-Frequency Cetaceans (harbor porpoises)	N/A	173 dB	120 dB	202 dB	155 dB	160 dB

Notes: cSEL = cumulative sound exposure level; dB = decibel; N/A = Not applicable, no thresholds exist; RMS = root mean square

a. The airborne disturbance guideline applies to hauled-out pinnipeds.

b. Level A threshold for impulse noise is a duel criterion based on peak pressure and cSEL. Thresholds are based on the NMFS 2018 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing.

Underwater peak and RMS are re: 1 µPa; cSEL is re: 1 µPa2-sec; Airborne RMS is re: 20 µPa.

Limited data are available on the behavioral effects of continuous noise on pinnipeds while underwater; however, field and captive studies to date collectively suggest that pinnipeds do not react strongly to exposures between 90 and 140 dB re: 1 micropascals (µPa) RMS (Southall et al. 2007). In addition, ambient underwater noise levels in urbanized estuaries often far exceed 120 dB RMS, because of the nearly continuous noise from recreational and commercial boat traffic. For example, ambient noise levels in Ellis Bay in the Puget Sound in Washington had reported peak levels of 147 to 156 dB and reported RMS levels of 132 to 143 dB (Caltrans 2015). Ellis Bay is characterized as a marine bay with heavy commercial boat traffic, similar to Coos Bay.

Background underwater sound levels in the project area are considered in the assessment of the LNG terminal’s construction impacts. Ambient noise levels have been used as a threshold for behavioral harassment from pile driving in other IHA authorizations, such as for the Mukilteo Multimodal Project Tank Farm Pier Removal in Washington (several authorizations, most recently authorized in 2018), and the Anacortes Ferry Terminal Tie-up Slip Dolphin and Wingwall Replacement Project in Washington (authorized on September 1, 2015). Underwater noise in Coos Bay is generated regularly by medium to large-sized boats. Site-specific ambient noise data were collected during the baseline surveys by AECOM in Coos Bay in May 2017 and November 2018. Underwater sound levels for water transit vessels, which operate throughout the day in Coos Bay, ranged from 152 dB to 177 dB. The results suggested that the ambient noise level was approximately 120 dB, with daily variability after taking the vessel traffic noise into consideration. Therefore, the standard Level B threshold of 120 dB RMS is used in this assessment.

5.2 Anticipated Airborne Noise

In-air noise would be generated at the project site by both general construction activities and from installation of support pilings and sheet pilings. The NMFS operational in-air threshold for Level B harassment from in-air noises is 90 dB RMS (re: 20 μPa) for phocid seals, and 100 dB RMS (re: 20 μPa) for otariids (Table 5-1). These are not official thresholds but are used as guidelines to determine impacts associated with changes in airborne noise levels. No analogous in-air threshold exists for cetaceans.

As a task associated with JCEP's FERC application, SLR Consulting (SLR) evaluated general construction noise levels for the LNG Terminal (see Appendix B). Based on this analysis, airborne noises produced by general construction activities would decrease to less than 90 dB approximately 150 meters from shore. Because no haul-outs are within 1 mile of the project site, no marine mammals would be disturbed by general construction noise occurring at the site. SLR also modeled in-air noise production from pipe pile driving (Appendix B). It determined that such noises would decrease to less than 90 dB RMS beyond approximately 280 meters from the pile-driving activity. Because no haul-outs are even within 1,000 meters of the project site, no marine mammals would be disturbed by pile-driving noise originating from the Marine Facilities site.

As described in Section 1.5.2, Ancillary Activities would occur at the TPP/US-101 site and the APCO sites. Aside from pile driving, the primary airborne noise-producing activities would be associated with the operation of heavy equipment loading, or offloading the materials barges based at each site. Based on data from the U.S. Department of Transportation (USDOT 2017), a backhoe would produce roughly 78 A-weighted decibels (dBA) (re: 20 μPa) at 15 meters. Although this noise measurement is in terms relative to human hearing, the in-air noise levels are sufficiently far below the NMFS 90 dB RMS threshold that airborne sounds at any seal haul-out site would be well below this threshold.

Dredging of the access channel would produce in-air noises. However, based on SLR's analysis (Appendix B), noise levels in air would decrease to below 90 dB RMS at distances on the order of 12 meters from the noise source. The access channel is adjacent to the LNG Terminal and given the high activity that will likely be occurring during construction, harbor seals are not likely to haul out along the shoreline in the vicinity. In-air noises from dredging are not anticipate to affect marine mammals.

In summary, JCEP does not expect any marine mammal to be affected by airborne noise generated from pile driving or other general construction activities, including dredging. Seals hauled out would be too far from the noise sources to be affected, while animals transiting through the estuary near the project site would perceive only airborne noise within approximately 150 meters of the project site, and then would be exposed only momentarily as they surface to breath. For these reasons, JCEP is not requesting take for harassment of marine mammals from airborne noise.

5.3 Anticipated Underwater Noise

A review of underwater sound measurements for similar projects was undertaken to estimate the near-source sound levels for vibratory pile driving and impact pile driving. Pile-driving sound levels from similar type and size of piles have been measured for other projects and can be used to estimate the noise levels that the LNG Terminal would generate. To estimate underwater noise levels for the LNG Terminal, measurements from a number of underwater pile-driving projects, conducted under similar circumstances (similar water depths in areas of similar substrate), were reviewed for use as source-level data. The following analysis applies the typical, conservative transmission loss factor of 15 (approximately 4.5 dB per doubling of distance) for underwater noise. NMFS recommends that a value of 15 be used unless a site-specific transmission loss has been measured (Caltrans 2015).

For in-water pile driving, this analysis uses the practical spreading loss model, which NMFS and the U.S. Fish and Wildlife Service have accepted to estimate transmission loss of sound through water. For on-land pile driving, this analysis uses a full-wave numerical sound propagation model, developed by JASCO, through its FWRAM software package (Appendix C). This model simulates the transmission of pile-driving noise through water-saturated soils into the water. For modeling the sound propagation, JASCO collected environmental data that describe the bathymetry, water sound speed, and seabed geoacoustics in Coos Bay. Both forms of analysis provide estimated distances over which the established Level A and Level B thresholds for underwater noise may be exceeded.

For impact-driving of steel piles that occurs in the water, bubble curtains or a dewatered cofferdam would be used to provide noise attenuation. A bubble curtain system creates a thick ring of fine bubbles around the pile, to impede and scatter noise radiating from the pile, acting as a barrier for the sound to pass through after the sound is radiated from the pile, and reducing the radiation of sound from the pile into the water by having the low-density bubbles very close to the pile (Caltrans 2015). Dewatered cofferdams work in a similar manner, by creating an airspace around the pile to decouple the direct interaction of the pile and the water column. Bubble curtains can be installed within the confinement of a pipe or be unconfined within the water column. The level of attenuation provided by a bubble curtain or dewatered cofferdam can vary greatly, depending on the size of the curtain or airspace, installation methods, and physical conditions of the site, including water current velocity, depth, and substrate type. Observed attenuation from such systems has ranged from 0 to 15 dB (Caltrans 2015). Recent guidance from Caltrans and the Marine Mammal Commission (Molnar 2018) indicates that an attenuation factor of 7 dB is a reasonable assumption for a properly operating bubble curtain system.

5.3.1 Land-Based Vibratory Driving at the LNG Terminal

Construction of the MOF and the southwestern end of the west berth wall would require installation of sheet piles near the water’s edge. In addition, six mooring piles would be installed into the berm at the TMBB. Before this vibratory driving, as discussed in Section 1, an approximately 10-meter wide earthen berm would be left in place between the water and the location of the piles. For both pile types, modeling conducted by JASCO was used to determine the distances over which Level A and Level B thresholds may be exceeded in the adjacent waters of Coos Bay. The sound source levels of vibratory driving of these sheet piles was assumed to be equivalent to the sound levels reported for Berth 23, Port of Oakland vibratory pile driving (conducted using an APE 400 3,200 kiloNewton vibratory hammer). More information regarding the model inputs and methods used by JASCO is provided in Appendix D. The distances to the Level B thresholds for this pile driving are shown in Figure 5-1 and Figure 5-2 and summarized in Table 5-2. Based on the JASCO model, the Level A thresholds were not exceeded for these pile driving activities (see Appendix C).

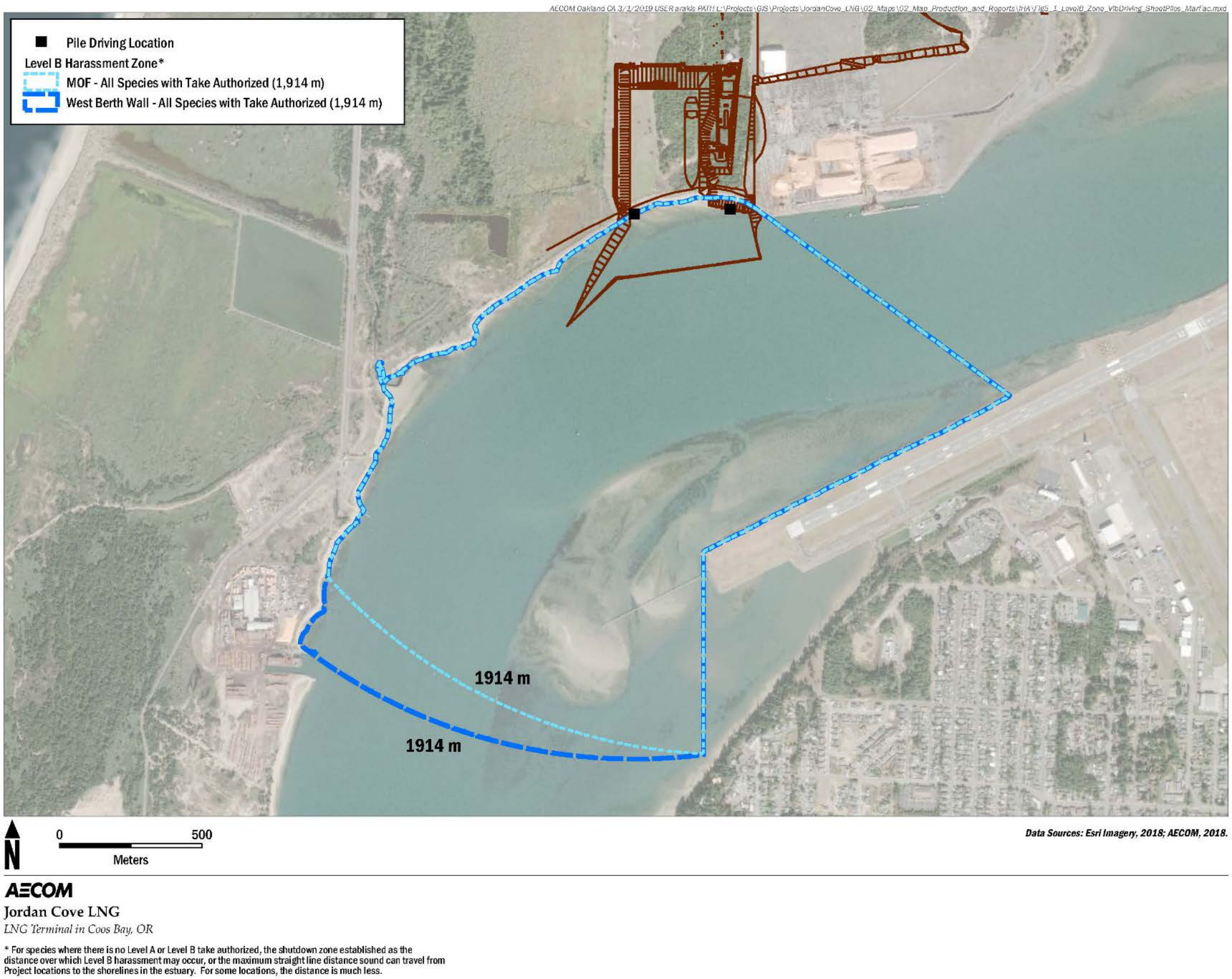
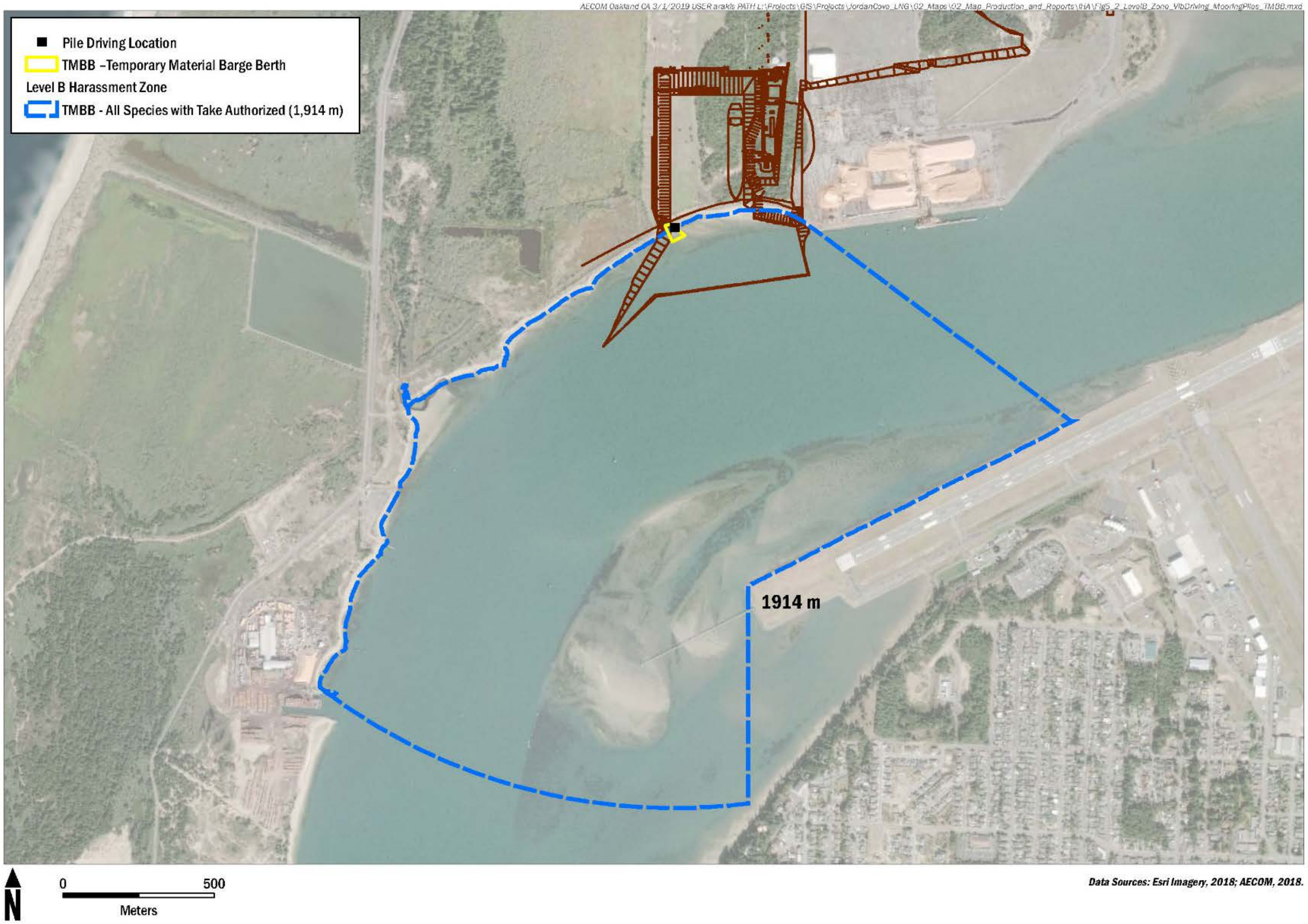


Figure 5-1. Level B Harassment Zone for Vibratory Driving of Sheet Piles at the MOF and West Berth Wall



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* For species where there is no Level A or Level B take authorized, the shutdown zone established as the distance over which Level B harassment may occur, or the maximum straight line distance sound can travel from Project locations to the shorelines in the estuary. For some locations, the distance is much less.

Figure 5-2. Level B Harassment Zone for Vibratory Driving of TMBB Mooring Piles

Table 5-2. Land-Based Vibratory Driving: Distances to Level A and Level B Thresholds at 0-Meter Setback

Hearing Group	Distance to Thresholds for Continuous Noise (approximately 5 hours driving per day at 0-meter setback)			
	Level A PTS Threshold, SEL*	Range (meters)	Level B Threshold, dB RMS	Range (meters)
MOF and SW West Berth Sheet Piles and TMBB Mooring Piles				
Phocid pinnipeds in water	201	NE	120	1,914
Otariid pinnipeds in water	219	NE		1,914
Low-frequency cetaceans	199	NE		1,914
Mid-frequency cetaceans	198	NE		1,914
High-frequency cetaceans	173	NE		1,914

Notes:
* Weighted SEL24h (dB re 1 µPa²·s)
dB = decibels; NE= not exceeded; PTS = permanent threshold shift; RMS = root mean square; SEL = sound exposure level

Modeling of land-based vibratory driving of the relatively few pipe piles at the TMBB was not conducted by JASCO, because the modeling done for land-based sheet piles is adequately transferrable. AECOM's review of available data (Caltrans 2015) established that noise from vibratory installation of 36-inch-diameter pipe piles would have similar frequency spectra and magnitude to the sound levels from vibratory installation of sheet piles at Berth 23, Port of Oakland, as described above. The best frequency spectra analog that could be located for vibratory installation is from pile driving that occurred at the Philadelphia Naval Yard. For that project, a similar vibratory pile driver was used to drive piles in water of similar depth, into similar substrate to the Berth 23 project. The source levels for 36-inch pipe piles would be a conservative estimate for the sound levels associated with the 24-inch pipe piles at the TMBB.

Overall, the spectra of the two pile types was similar, with the primary difference being that for the 36-inch steel shell pile, the peak of approximately 148 dB was present at about 25 hertz (Hz), whereas the highest peak of approximately 148 dB for the sheet pile occurred at 940 Hz. The sheet pile did produce some peaks below 100 Hz, but the magnitude was approximately 10 dB lower. In terms of overall RMS and SEL values, the sheet piles were slightly higher when compared to the pipe piles.

Unlike impact driving, a simple relationship between pile size and underwater noise source levels for vibratory driving does not exist. The harmonic vibration of the pile, and therefore the noise it generates, are controlled by the stiffness of the pile, its length, and the characteristics of the vibratory driver used. Because sheet piles have a lower lateral stiffness than a round pile, it is reasonable to assume that the noise levels may be similar, despite the steel shell pile having more surface area and mass.

Other sources (Caltrans 2015) show sound levels measured from land-based vibratory driving of 36-inch piles. The sound levels that were measured at a 20-meter range (150 dB) are about 5 dB lower than the sound levels modeled from sheet piles at a 20-meter range (155 dB). Therefore, it is scientifically supportable (and conservative) to use results from existing modeling of vibratory pile driving to represent the sound levels from vibratory driving of 36-inch pipe piles. Also, in-the-dry vibratory piling is not expected to exceed the Level A thresholds for auditory injury, so it was deemed unnecessary to calculate species-specific thresholds for this activity. The only NOAA threshold of concern for vibratory piles would be the 120 dB behavioral disturbance threshold (sound level pressure [SPL]) for continuous sounds. No species-specific disturbance thresholds are applicable to vibratory piling.

5.3.2 Impact Driving at the Ancillary Activities

Impact driving may be used to install thirty-six 24-inch steel shell piles at the TPP/US-101 intersection. JCEP expects that four piles may be installed per day, with each pile requiring 200 blows from an impact driver, for a total of 800 blows per day. These piles are expected to be driven into sandy substrate, where water depths are a meter or less deep. For this activity, the practical spreading model was used to estimate the distances over which underwater noise thresholds may be exceeded. The best fit for source levels comes from the summary values provided by Caltrans (Caltrans 2015). For this pile type and size, maximum values of 203 Peak, 190 RMS, and 177 SEL were recorded. A dewatered cofferdam or bubble curtain would be used to attenuate underwater noise during impact driving, which is expected to reduce underwater noise levels by 7 dB, on average. This expectation is based conservatively on the attenuation provided by a bubble curtain, as it works in a similar manner by decoupling the pile from the water column. Therefore, the source values used in this analysis are 196 Peak, 183 RMS, and 170 SEL. Based on these anticipated levels, installation of the 24-inch steel shell piles are expected to produce underwater sound exceeding the Level B 160 dB RMS threshold over the distances summarized in Table 5-3 and the areas shown in Figure 5-3. Cumulative noise from impact driving of these piles could produce noise levels above the Level A threshold over the relatively short distances shown in Table 5-4 and Figure 5-3.

Work at the TPP also would require installation of approximately 1,150 untreated timber pilings, which would be installed with an impact hammer behind a partially dewatered sheet pile cofferdam. Twenty of these piles are expected to be installed per day, each requiring 100 blows from an impact hammer, for a total of 2,000 blows per day. These piles are expected to be driven into mud and sandy substrate, where water depths will be 0.3 meter or less. For this activity, the practical spreading model was used to estimate the distances over which underwater noise thresholds may be exceeded. The best fit for source levels comes from the installation of 14-inch timber piles at the Ballena Bay Marina in Alameda, California. During monitoring of those piles, maximum values of 180 Peak, 170 RMS, and 160 SEL were recorded when using a 3,000-pound drop hammer (Caltrans 2015). Because the cofferdam would not be fully dewatered and no bubble curtain would be used for this piling activity, no attenuation of these source levels is assumed for this analysis. Based on these anticipated levels, installation of the 14-inch timber piles are expected to produce underwater sound exceeding the Level B 160 dB RMS threshold over the distances summarized in Table 5-3 and the areas shown in Figure 5-4. Cumulative noise from impact driving of these piles could produce noise levels above the Level A threshold over the relatively short distances shown in Table 5-4 and Figure 5-4.

5.3.3 Vibratory Driving at the Ancillary Activities

Vibratory driving would be used to install 24-inch steel pipe piles at the APCO sites, as summarized in Table 1-3. JCEP expects that four piles may be installed per day, with each pile requiring 7.5 minutes of driving from a vibratory driver, for a total of 30 minutes per day. These piles are expected to be driven into mud or sandy substrate, where water depths are less than a meter deep. For this activity, the practical spreading model was used to estimate the distances over which underwater noise thresholds may be exceeded.

Table 5-3. Estimated Pile-Driving Noise Levels and Level B Threshold Exceedance Using Practical Spreading Model

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level B Threshold, in meters[a]	Area of Threshold Exceedance (sq. km)
	Peak	RMS	160/120 dB RMS Threshold (Level B)[b]	
24-inch Pipe Piles at TPP/US-101–Impact with BCA	196*	183*	341	0.136
14-inch Timber Piles at TPP/US-101–Impact within cofferdam	180	170	46	0.002
24-inch Pipe Piles at TPP/US-101, and APCO sites – Vibratory	191	165	10,000	TPP/US101 – 1.18 APCO – 0.40
14-inch Timber Piles at TPP/US-101 – Vibratory	172	162	6,310	1.18
Sheet Piles at TPP/US-101 – Vibratory	175	160	4,642	1.18

Notes:

* Assumes a 7dB reduction in source levels due to bubble curtain attenuation (BCA).

a. Theoretical distance, applicable where noise will not be blocked by land masses or other solid structures.

b. For underwater noise, the Level B harassment (disturbance) threshold is 160 dB for impulsive noise and 120 dB for continuous noise.

Peak and RMS are re: 1 µPa.

Table 5-4. Estimated Pile-Driving Noise Levels and Distances of Level A Threshold Exceedance Using Practical Spreading Model

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level A Threshold[a], in meters[b]				
	Peak[c]	RMS/SEL	Phocids	Otariids	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans
24-inch Pipe Piles TPP/US-101 Intersection – Impact with BCA	196*	170 SEL*	63	5	117	4	139
14-inch Timber Piles at TPP/ US-101– Impact within cofferdam	180	160 SEL	25	2	46	2	55
24-inch Pipe Piles at TPP/US-101 and APCO sites – Vibratory	191	165 RMS	5	<1	8	1	12
14-inch Timber Piles at TPP/ US-101 – Vibratory	172	162 RMS	7	<1	11	1	17
Sheet Piles at TPP/US-101 Vibratory	175	160 RMS	5	<1	8	1	12

Notes:

* Assumes a 7dB reduction in source levels due to bubble curtain attenuation (BCA).

a. Level A thresholds are based on the NMFS 2018 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing; cSEL threshold distances are shown. See footnote 3 below.

b. Where noise will not be blocked by land masses or other solid structures.

c. All distances to the peak Level A thresholds are less than the calculated distances to the cSEL thresholds.

Distances are rounded to the nearest meter or to “<1.0” for values less than 1 meter.

Figure 5-3. Level A and B Harassment Zones for Impact Driving of Steel Pile Piles at TPP/US-101 Intersection

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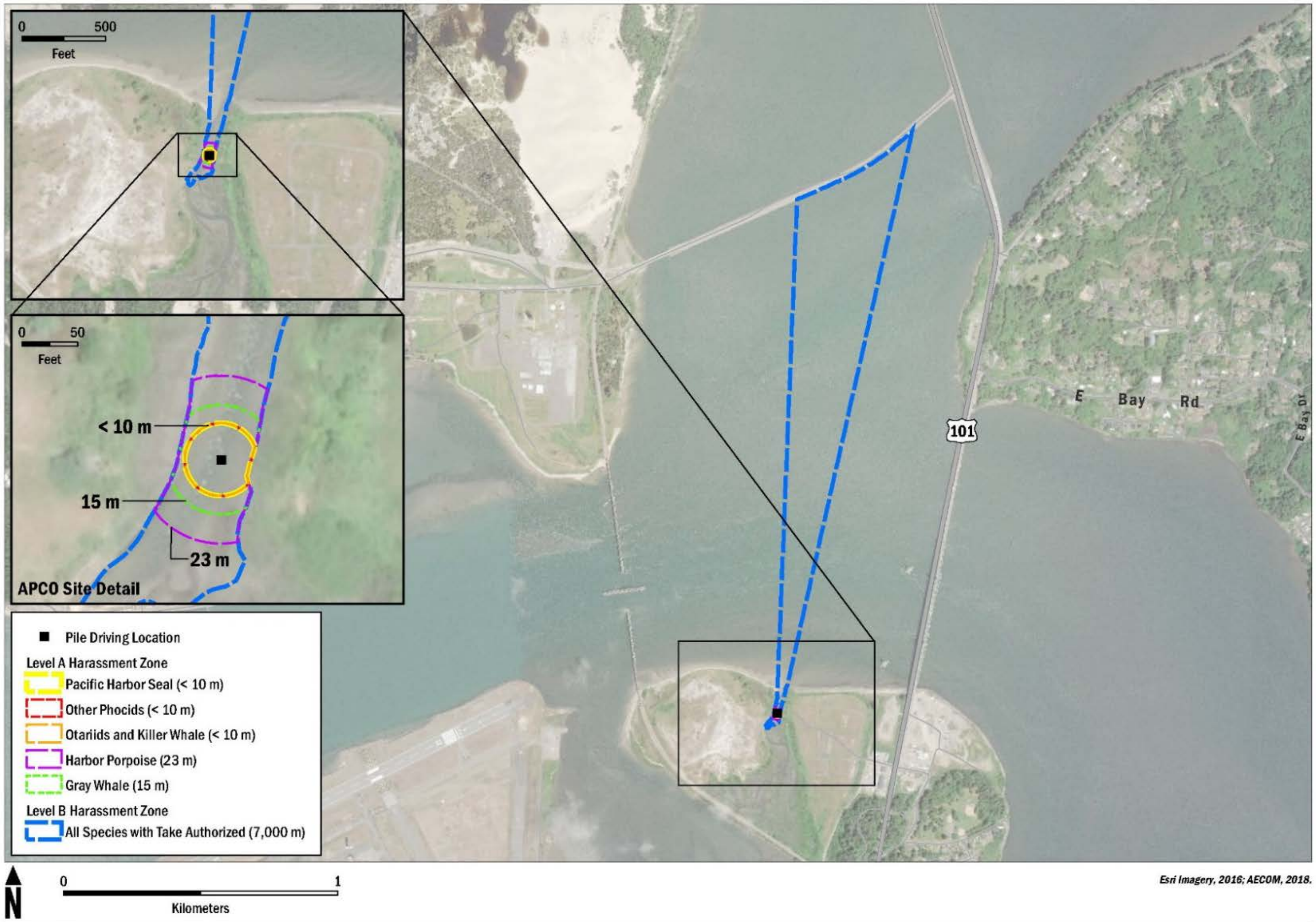
* For species where there is no Level A or Level B take authorized, the shutdown zone established as the distance over which Level B harassment may occur, or the maximum straight line distance sound can travel from Project locations to the shorelines in the estuary. For some locations, the distance is much less.

Figure 5-4. Level A and B Harassment Zones for Impact Driving of Timber Piles at TPP/US-101 Intersection

The best match for estimated noise levels is from vibratory driving of 24-inch piles at the Explosive Handling Wharf-2 project at the Naval Base Kitsap in Bangor, Washington (Caltrans 2015). During vibratory pile-driving associated with this project, which occurred under similar circumstances, measured peak noise levels were approximately 180 dB, and the RMS and SEL were both approximately 165 dB at a 10-meter (33-foot) distance (Caltrans 2015). Based on these anticipated levels, vibratory installation of the 24-inch steel shell piles is expected to produce underwater sound exceeding the Level A and Level B thresholds over the distances shown in Table 5-3 (Level B) and Table 5-4 (Level A), and the areas shown in Figure 5-5 for the APCO sites.

Vibratory driving also would be used to install steel sheet piles for construction of a cofferdam at the TPP/US-101 intersection (Table 1-3). Twenty piles are expected to be installed per day, with each pile requiring 5 minutes of driving from a vibratory driver, for a total of 100 minutes per day. These piles are expected to be driven into mud and sandy substrate, where water depths would be 0.3 meter or less. For this activity, the practical spreading model was used to estimate the distances over which underwater noise thresholds may be exceeded. The best match for estimated noise levels is from the Caltrans Summary of Sound Pressure Levels for In-Water Pile Installation Using a Vibratory Driver (Caltrans 2015). There, Caltrans reports typical anticipated peak noise levels of 175 dB, RMS of 160 dB, and an SEL of 160 dB at 10m (Caltrans 2015). Based on these anticipated levels, vibratory installation of the 24-inch steel sheet piles are expected to produce underwater sound exceeding the Level B 120 dB RMS threshold over the distances shown in Table 5-3 and the areas shown in Figure 5-6. Cumulative noise from vibratory driving of these piles could produce noise levels above the Level A threshold over the relatively short distances shown in Table 5-4 and Figure 5-6.

Furthermore, vibratory driving also may be used to install the approximately 1,150 untreated timber pilings at the TPP/US-101 intersection, which would be installed behind a sheet pile cofferdam. JCEP expects that 20 piles may be installed per day, with each pile requiring 5 minutes of driving from a vibratory driver, for a total of 100 minutes per day. These piles would be driven behind a cofferdam in an area of mud and sandy substrate, where water depths would be 0.3 meter or less. For this activity, the practical spreading model was used to estimate the distances over which underwater noise thresholds may be exceeded. The best match for estimated noise levels is from vibratory installation of timber piles at the Norfolk Naval Station in Norfolk, Virginia. During vibratory pile driving associated with this project, measured peak noise levels were approximately 172 dB, and the RMS and SEL were both approximately 162 dB at a 10-meter (33-foot) distance (Caltrans 2015). Because the cofferdam would not be fully dewatered and no bubble curtain would be used for this piling activity, no attenuation of these source levels is assumed for this analysis. Based on these anticipated levels, vibratory installation of the 24-inch steel sheet piles are expected to produce underwater sound exceeding the Level B 120 dB RMS threshold over the distances shown in Table 5-3 and the areas shown in Figure 5-6. Cumulative noise from vibratory driving of these piles could produce noise levels above the Level A threshold over the relatively short distances shown in Table 5-4 and Figure 5-6.



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* For species where there is no Level A or Level B take authorized, the shutdown zone established as the distance over which Level B harassment may occur, or the maximum straight line distance sound can travel from Project locations to the shorelines in the estuary. For some locations, the distance is much less.

Figure 5-5. Level A and B Harassment Zones for Vibratory Driving of Piles at the APCO Sites

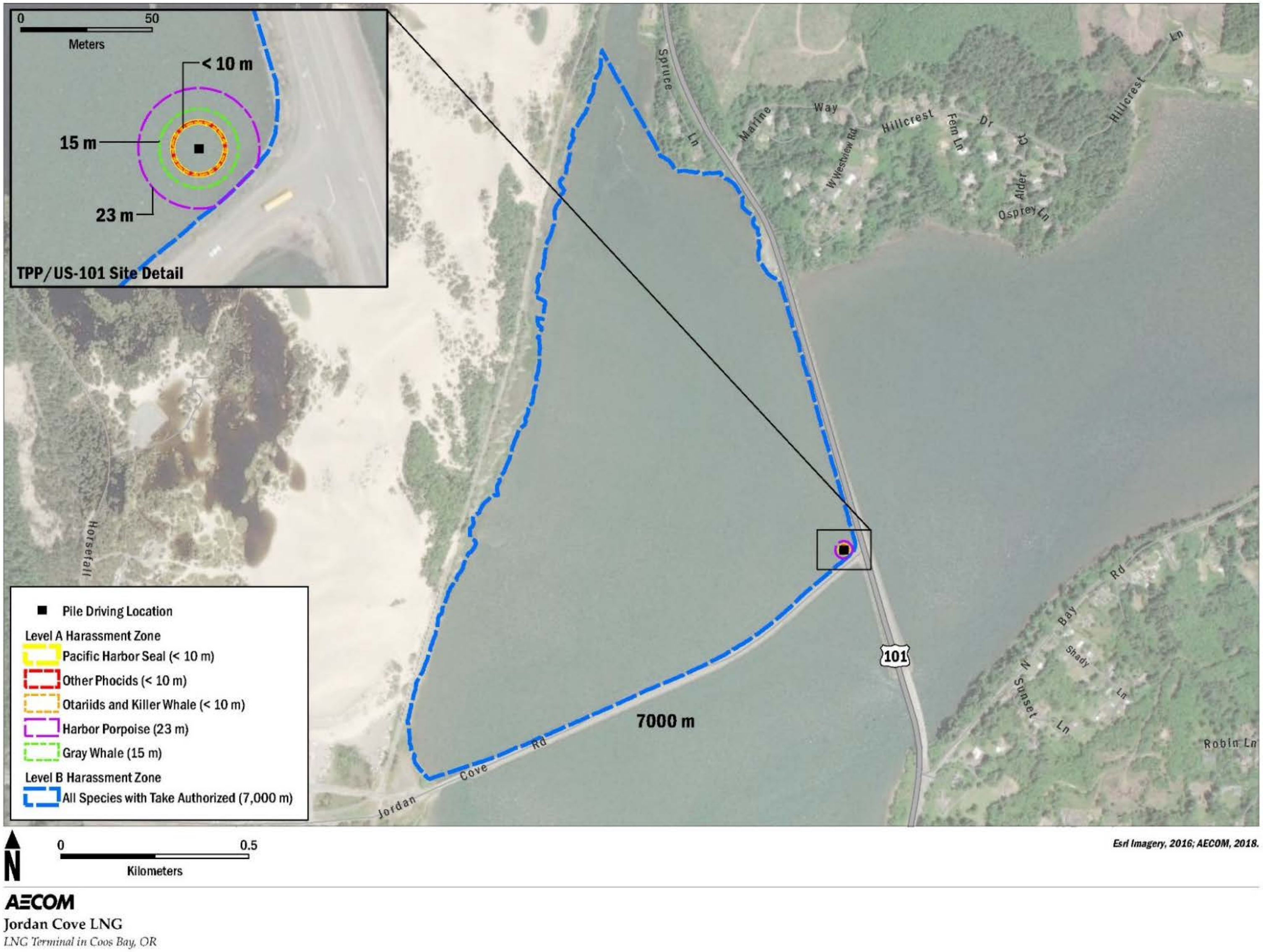

Figure 5-6. Level A and B Harassment Zones for Vibratory Driving of Pipe, Timber and Sheet Piles at TPP/US-101 Intersection

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6. Take Estimated for Marine Mammals

"By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in paragraph (a)(5) of this section, and the number of times such takings by each type of taking are likely to occur." (50 CFR Section 216.104[a][6])

6.1 Harbor Seals

The typical method for estimating per-day harassment from pile driving activities is to multiply the Zone of Influence[1] (ZOI) or the area of the Level A or Level B zone by an estimated in-water density (animals per area). Using the latest available guidance from NMFS, the Level B ZOI is defined using the single-strike RMS threshold of 160 dB for impact driving, or the 1-second RMS threshold of 120 dB for vibratory driving. The Level A ZOI is defined using the cSEL thresholds that NMFS has established for the various hearing groups of marine mammals (i.e., pinnipeds, high-, mid- and low- frequency cetaceans). This method assumes that the position of an individual animal is static for the duration of active pile driving each work day, and the animals are distributed uniformly throughout the study area. Although marine mammals are highly mobile in the water, may travel far distances to forage, and often travel in groups or are concentrated around food resources, these limitations are acceptable for projects that are driving relatively few piles, are not occurring near any haul-outs or known areas of animal concentration, or when active pile driving would be occurring for a very short period per work day. In this instance, this method is suitable for the Ancillary Activities because they would be limited in duration or would occur in areas where harbor seals are not expected to traverse frequently.

However, the inputs described above are not directly applicable for estimating harbor seal take resulting from the vibratory pile driving that is planned at the LNG Terminal, because of the following factors:

- Active vibratory driving may be occurring for a total of several hours per day.
- Because Coos Bay is narrow, level B noise thresholds are expected to be exceeded across the width of Coos Bay (Figure 2-1), so that harbor seals moving between the lower and upper part of the estuary could not avoid the ZOI.
- Many harbor seals that haul out at Clam Island, and to a lesser extent, the other haul-outs in Coos Bay, would be likely to swim by the LNG Terminal work zone on a daily basis, to forage in the upper portions of the estuary while active pile driving is occurring.

Because of these factors, individual animals are expected to move into the Level B ZOI throughout the day as active vibratory driving is occurring at the LNG Terminal, and harbor seal take would be underestimated without accounting for the movement of animals. To address this issue, a method to estimate take has been developed that accounts for the movement of harbor seals and the extensive pile driving activities that are anticipated for the LNG Terminal. This concept is not applicable to the Level A zones during vibratory driving because those thresholds

[1] ZOI refers to the Zone of Influence – the area over which the harassment threshold would be exceeded (i.e., 120 dB Level B threshold for vibratory driving), as calculated using GIS, using the radii produced by the practical spreading model tool provided by NMFS, or as calculated by JASCO.

would be exceeded over very short distances (less than 10 meters), if at all. Similarly, this modified method is not needed for impact driving as the Level B zones generally would be smaller, and impact pile driving would be limited to a relatively small number of piles in the overall pile driving schedule.

This “movement” method uses the same base assumption as the typical “static” method described above—that harbor seals are distributed evenly across the estuary. However, this method then assumes that these evenly distributed harbor seals travel through the harassment zones carried by tidal currents. Thus, take for each day is calculated by taking a “snapshot” of the seals that are in the ZOI when driving starts, and then adding to that the seals that “flow” into the leading edge of the ZOI for the duration of pile driving. After harbor seals flow across the leading edge of the ZOI, they are considered taken.

Using the “movement” method, the formula for daily take estimate accounting for harbor seal movement is as follows:

Seals/km^2 × (ZOI) km^2 + Seals/km^2 × (Current) km/min × (Pile Driving) min/day × (Channel Width) km = Seals/day

The inputs for Level B take are as follows:

- Inside ODFW in-water work window (October 1 to February 15) Seals/km^2 = 167/55.28 = 3.0 (see Section 4.1)
- Outside ODFW in-water work window (February 16 to September 30) Seals/km^2 = 342.5/55.28 = 6.2 (see Section 4.1)
- ZOI km^2 = varies with pile type (MOF sheet piles have a Level B ZOI of 2.49 km^2; for example, see Figure 6-1)
- Average current = 1.4 kilometers/60 minutes (as modeled by Moffatt & Nichol 2017)
- Driving minute per day = minutes varies with pile type (for MOF sheet piles, the value is 309 minutes, as provided by construction contractor)
- Channel width = 1.1 kilometers (measured using GIS, perpendicular from the current shoreline where the LNG terminal would be located)

This “movement” method of Level B take estimation would be applied to all vibratory pile driving at the LNG Terminal, as well as to vibratory installation of the piles needed at the four NRI locations. The “static” method of take estimation would be applied to the remainder of the Ancillary Activities pile driving, as discussed in Section 1.5.2.

Using the above methods, the Level B harbor seal takes are summarized in Table 6-1. The Year 1 data are based on an assumed July 1 Notice to Proceed and October 1 start of pile driving activities. The standard procedure that NMFS uses is to hold all rounding on take numbers to the final total of the estimate (rounding is not done for each activity type). Since shutdown zones that are larger than the Level A zones modeled in Section 5.3 would be implemented, No Level A take of harbor seal is requested.

The number of Level B incidental take of Pacific harbor seal (approximately 8,750, as shown in Table 6-1) would be spread out over approximately 230 days of pile driving. The average estimated take per day is about 38 individuals, which represents only a fraction of the harbor seal stock that occupies the Oregon/Washington coast. The latest population estimate for that stock is approximately 16,165 individuals (Table 4-1). The harbor seals that occupy the Coos Bay estuary haul out sites number approximately 343 animals during the peak seasons and account for approximately 2 percent of the Oregon/Washington stock. An even smaller portion of the population would be affected during work activities that will occur outside the peak pupping season (late spring/early summer), when the numbers within the estuary waters decrease. Because harbor seals can display relatively high site fidelity to their haul out sites, it is possible that some portion of the 2 percent of the population may experience repeated instances of Level B takes over each year of pile driving. Thus, the vast majority (98 percent) of the Oregon/Washington stock of harbor seals would be unaffected by the project.

6.2 Other Marine Mammals

Six other species of marine mammals have a low potential to be present in Coos Bay, as described in Sections 3 and 4. JCEP would stop pile driving activity if one or more individuals from one of these six species were about to enter the applicable Level A harassment zone around each activity, so no Level A take of these species is requested. Insufficient data are available to estimate take for these species using in-water population densities or similar means. Thus, take estimates for these species have been developed based on the expected intervals of occurrence in Coos Bay and the typical group size of the stock.

Northern elephant seal: These animals forage individually and generally hunt in deep waters off the coast. Although no regular haul-outs are found for these species in Coos Bay, the species irregularly haul out near Cape Arago, and juveniles occasionally may strand in Coos Bay. Table 6-2 shows the estimated take anticipated, assuming that one individual enters a Level B harassment zone during each week of active pile driving.

California sea lion: These animals forage individually but may congregate where food resources are concentrated. Although no regular haul-outs are found for these species in Coos Bay, seasonal use at Cape Arago occurs, with hundreds of animals often present. Table 6-2 shows the total anticipated take for this species, assuming that one individual may enter a Level B harassment zone during each day of active pile driving.

Steller sea lion: These animals forage individually but may congregate where food resources are concentrated. Although no regular haul-outs are found for this species in Coos Bay, seasonal use at Cape Arago occurs, with hundreds of animals often present. Table 6-2 shows the total anticipated take for Steller sea lion, assuming that one individual of each species enters a Level B harassment zone during each day of active pile driving.

Gray whale: During migration, the species typically travels singly or as a mother and calf pair. This species has been reported in Coos Bay only a few times in the last decade (Section 3.1), and thus take of up to two individuals is requested as a contingency (Table 6-2).

Killer whale: The typical group size for this species is two to four, consisting of a mother and her offspring (Orca Network 2018). Males and young females also may form small groups of around three for hunting purposes (Orca Network 2018). Table 6-2 shows the estimated take, assuming that a group of three killer whales come into Coos Bay and enters a Level B harassment zone for one day up to five times per year.

Harbor porpoise: The average reported group size for harbor porpoise is two to five. Table 6-2 shows the anticipated take, assuming one group of four animals comes into a Level B harassment zone approximately three times per year.

Table 6-1. Estimated Harbor Seal Take, 2020/2021 Work Year 1

Method	Pile Type	Total Piles	Location	Animal Density[a]	Driving Days	Mins Driving per Day	Level B Zone Area from GIS (sq. km)[b]	Level B Takes Per Day[a]	Total Level B Takes (Year 1)[b]	Calculation Method
LNG Terminal Piles										
Vibratory	Sheet Pile	1,246	MOF (outside ODFW work window)	6.2	97	309	2.49	64.52	6,258.44	**Movement**
Vibratory	Sheet Pile	623	MOF (inside ODFW work window)	3.0	48	309	2.49	31.66	1,519.68	**Movement**
Vibratory	Sheet Pile	113	W. berth wall, 2.5% nearest berm (outside ODFW work window)	6.2	8.5	329	2.49	66.34	563.89	**Movement**
Vibratory	Pipe Pile	6	TMBB mooring pile (inside ODFW window)	3.0	10	9	3.19	9.64	96.40	**Static**
Ancillary Activities Piles (all inside ODFW window)										
Impact	Timber	1,150	TPP/US-101 intersection	3.0	60	50	NA	NA	NA	**Static**
Vibratory	Timber	1,150	TPP/US-101 intersection	3.0	60	100	1.18	3.58	214.80	**Static**
Vibratory	Sheet Pile	311	TPP/US-101 intersection	3.0	16	100	1.18	3.58	57.28	**Static**
Impact	Pipe Pile	36	TPP/US-101 intersection	3.0	9	20	NA[c]	NA	NA	**Static**
Vibratory	Pipe Pile	36	TPP/US-101 intersection	3.0	9	80	1.18	3.58	32.22	**Static**
Vibratory	Pipe Pile	33	APCO sites	3.0	9	30	0.40	1.20	10.80	**Static**
								Grand Total	**8,753.51**	

Notes:

NE – Not Exceeded

a. Animal density is determined whether the work will be conducted inside the ODFW work window or outside of the ODFW work window. See Level B inputs above.

b. The distance to the Level B thresholds for land-based pile driving are based on 0-m setback ZOIs. Through the enforcement of shutdown zones that are larger than the Level A harassment zones, no Level A take would occur.

c. "NA" is indicating "Not Applicable." The Level B take is calculated from vibratory driving only as that provides the worst case scenario. The Level B zones for vibratory driving are larger than the impact driving zones for the same pile type. This is because of the higher threshold for impact driving (160 dB) versus vibratory driving (120 dB).

Table 6-2. Summary of Estimated Take Request for All Marine Mammal Species

Species	Level A Harassment	Level B Harassment	Stock Population[a]	Percent of Stock
Pacific harbor seal	0	8,754 (343 Coos Bay population)[b]	16,165	2%[b]
Northern elephant seal	0	33	179,000	<1%
California sea lion	0	230	296,750	<1%
Steller sea lion (Eastern DPS)	0	230	52,139	<1%
Gray whale (Eastern North Pacific DPS)	0	2	20,990	<1%
Killer whale (transient)	0	15	243	6%
Harbor porpoise	0	12	35,769	<1%

Notes:

a. Taken from NMFS Stock Assessment Reports available at https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock.

b. The haul-outs in Coos Bay support, on average, approximately 343 animals which is the number used to determine the percent of stock impacted.

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7. Anticipated Impact of the Activity

“The anticipated impact of the activity upon the species or stock of marine mammals.” (50 CFR Section 216.104[a][7])

The project will produce underwater noise that potentially may harass marine mammals, as described in Section 5. The estimated Level B take by such harassment, as estimated in Section 6, is low when compared to the overall size of the affected stocks presented in Section 3. For most species, only a very small, fractional percentage of the affected stocks may be taken (Table 6-2).

For harbor seal, the amount of total take is estimated to be much larger than any other species, but still represents a small percentage of the affected stock (see Section 6.1). Because harbor seals are common in the Coos Bay estuary, it is reasonable to expect that some harbor seals would pass by the LNG Terminal pile driving and quickly would habituate to the noise, and thus would display little or no behavioral responses while in the Level B harassment zone.

NMFS recently has begun to issue Level A take regularly for pile driving, a change brought about by the 2016 Technical Guidance for Assessing the Effects of Anthropogenic Noise on Marine Mammal Hearing (and later revised in 2018), which adopted accumulative noise threshold for Level A take. The justification NMFS uses for issuing Level A take under the MMPA recognizes that the SEL PTS Level A thresholds are based on an accumulated exposure of the animal to elevated sound levels. Although NMFS treats a take of a marine mammal as instantaneous after it enters an established ZOI, it recognizes that the biological effects of the accumulated sound levels technically would not be realized unless the animal remains in the ZOI for an extended period, which is unlikely given their transient nature. No Level A take is requested for Year 1 pile driving activities.

7.1 Zone of Hearing Loss, Discomfort, or Injury

The zone of hearing loss, discomfort, or injury is the area in which the received sound energy is potentially high enough to cause discomfort or tissue damage to auditory or other systems. The possible effects of damaging sound energy are a temporary hearing threshold shift,[2] a temporary loss in hearing, PTS, and a loss in hearing at specific frequencies, or deafness. Non-auditory physiological effects or injuries that theoretically can occur in marine mammals exposed to strong underwater noise are stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. These effects would be considered Level A harassment; applicable NMFS acoustic thresholds for this type of harassment are species-specific, depending on the hearing group, and use duel-criteria metrics, including peak pressure and cSEL. The Level A harassment thresholds are shown in Table 6-1, and the distances to those thresholds are shown in Tables 6-2 through 6-4. These distances are considered to be very conservative, because they are based on cumulative noise from a full day of pile driving, and an animal would have to be present within that distance for an extended period to potentially experience PTS.

[2] On exposure to noise, the hearing sensitivity may decrease as a measure of protection. This process is referred to as a shift in the threshold of hearing, meaning that only sounds louder than a certain level will be heard. The shift may be temporary or permanent.

Vibratory pile-driving does not generate high-peak SPLs commonly associated with physiological damage. Through the implementation of the mitigation and monitoring described in Sections 11 and 13 (respectively), PTS or other physiological responses (i.e., Level A harassment) from pile-driving operations would be avoided for all species.

7.2 Zone of Masking

The zone of masking is the area in which noise may interfere with the detection of other sounds, including communication calls, prey sounds, and other environmental sounds. This effect would be considered Level B harassment; the applicable thresholds for the zone where this effect occurs are 160 dB for impulse sounds (i.e., impact pile driving), and 120 dB for continuous sounds (i.e., vibratory pile driving).

Other than killer whales, the marine mammals reviewed in this document are considered solitary foragers; however, underwater communicative signals for social reasons or predator avoidance may be disrupted during pile-driving activity that could lead to adverse effects. Pinniped communication occurs mostly in low-frequency signals underwater (NMFS 2010). Harbor porpoises are considered to be high-frequency cetaceans with an estimated auditory bandwidth range from 200 Hz to 180 kilohertz (kHz). Gray whales, like other baleen whales, are in the low-frequency hearing group. Underwater sounds produced by gray whales range from 20 Hz to 20 kHz (NMFS 2010). Killer whales, on the other hand, have hearing and vocalizations in a mid-frequency range. Coos Bay contains several industrial maritime facilities; other vessels and anthropogenic background noise in the project area may mask some construction sounds generated by the project.

7.3 Zone of Responsiveness

The zone of responsiveness is the area in which animals react behaviorally. The behavioral responses of marine mammals to noise or visual stimuli depend on a number of factors, including: (1) the acoustic characteristics of the noise source of interest; (2) the physical and behavioral state of the animals at the time of exposure; (3) the ambient acoustic and ecological characteristics of the environment; and (4) the context of the noise (e.g., does it sound like a predator?) (Richardson et al. 1995; Southall et al. 2007). However, temporary behavioral effects often are simply evidence that an animal has heard and reacted to a noise and may not indicate lasting consequence for exposed individuals (Southall et al. 2007). These types of effects would be considered Level B harassment; the applicable NMFS established thresholds for the zone where these effects occur are 160 dB for impulse sounds and 120 dB for continuous sounds.

In Graybill’s surveys (1981), he noted that harbor seals hauled out in the Coos Bay estuary were strongly affected by human disturbance. “The harbor seal by nature is a very shy animal, and hauled out seals are very difficult to approach either by boat or on foot…Seals at the North Spit and Pigeon Point haul outs are most frequently disturbed.” The North Spit/Clam Island area is frequented by humans digging for clams, with up to several hundred people in the vicinity of the haul-outs. Graybill noted, “Seals left the haul-outs when clammers were nearby and typically did not haul out again that day (North Spit), or hauled out shortly after all the clammers had left (Pigeon Point).”

He also reported regularly hearing gunshots during duck hunting season and noted that seals’ responses ranged from no response to all the seals fleeing into the water. Furthermore, he noted that an abundance of small recreational boats was in the area of the haul-outs, and that seals left the haul-outs if people were fishing near the haul-outs or if small boats passed close to the haul-outs. This skittishness is the simplest explanation for the seemingly inconsistent data shown in Figure 4-1 for aerial surveys of harbor seals in Coos Bay in 1984 and 1985. Graybill noted that the seals' behavior was unaffected by large boats or ships, "probably because these vessels stayed within the deep channel and did not approach close enough to cause a disturbance." This observation suggests that seals are more affected by the physical presence of perceived or potential predators than by the noises that they commonly experience in their environment. During the 2017-2018 field efforts by AECOM, the harbor seals were not observed to be disturbed by vessel activity, however, the researchers took measures not to disturb the wildlife during field activities. Similar measures were taken during the 2018 drone photographic field work to ensure that the data collection did not result in disturbance to marine mammals.

7.4 Zone of Audibility

The zone of audibility is the area in which the marine mammal may hear the noise. Marine mammals as a group have functional hearing ranges of 10 Hz to 180 kHz, with best thresholds near 40 dB (Southall et al. 2007). The Level A harassment thresholds capture the different hearing groups that are present in Coos Bay. No thresholds apply to the zone of audibility, because it is difficult to determine the audibility of a particular noise for a particular species. This zone does not fall within the noise range of a take as defined by NMFS. The zone of audibility also is limited by background noise levels, which may mask the particular noise in question. Background noise is produced both by natural (waves, rain, and other organisms) and anthropogenic sources (watercraft, bridges).

7.5 Expected Responses to Pile Driving

With both vibratory and impact pile-driving, the onset of activities would be likely to result in temporary, short-term changes in typical behavior, and/or avoidance of the affected area. A marine mammal may show signs that it is startled by the noise, and/or may swim away from the noise source and avoid the area. Other potential behavioral changes could include increased swimming speed, increased surfacing time, and decreased foraging in the affected area. Pinnipeds may increase their haul-out time, possibly to avoid in-water disturbance. Because active pile driving would occur for a just few hours a day, it would be unlikely to cause the permanent displacement of animals. Individual marine mammals potentially could experience impacts from pile-driving activities, but these activities would not cause population-level impacts or affect the long-term fitness of the species in Coos Bay. Harbor seal populations continue to thrive in many heavily industrialized estuaries, such as San Francisco Bay and the Columbia River, where dredging and construction involving pile driving happens on a regular basis.

The expected responses to pile-driving noise depend partly on the average ambient background noise of the site. Coos Bay experiences frequent dredging, ship traffic, hunting, clamming, or fishing on the shorelines, and other recreational uses. For marine mammals that use Coos Bay regularly, such as the harbor seals, responses to noise may be lessened because of habituation.

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8. Anticipated Impacts on Subsistence Use

"The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses." (50 CFR Section 216.104[a][8])

These activities would not take place in or near a traditional Arctic subsistence hunting area, nor would they affect stocks of marine mammals that contribute to Arctic subsistence hunting. Therefore, no impacts on subsistence uses of marine mammals would occur.

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9. Anticipated Impacts on Habitat

"The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat." (50 CFR Section 216.104[a][9])

In addition to the temporary noise effects of pile driving described in Section 5, potential project-related impacts on the estuarine habitat of Coos Bay would include the direct modification of habitat from construction-related dredging, scour and overwater shading; turbidity generated by project construction and operation; the entrainment and impingement of plankton and small fish for vessel cooling intakes; and the introduction of invasive estuarine species.

9.1 Habitat Modification from Dredging, Scour, and Overwater Structures

The construction of the LNG Terminal marine slip and access channel would affect local aquatic resources by removal or conversion of some habitats. About 36.7 acres of current upland habitat would be converted to open water—primarily deep subtidal habitat—during construction of the marine slip. Development of the LNG Terminal access channel and MOF would affect about 39.8 acres of estuarine habitat. About 14.76 acres of intertidal to shallow subtidal habitat, including 1.9 acres of eelgrass habitat and 0.06 acre of salt marsh, would be modified permanently to primarily deep subtidal habitat during the dredging process of the deepened channel. In addition, about 2.3 acres of intertidal, eelgrass, and subtidal habitat would be covered by a 3-foot-thick layer of rock, converting the habitat from a soft sediment to rocky habitat and altering the benthic community in that area.

Eelgrass is an important ecological component in Coos Bay, providing a nursery ground for many species that may be prey items for marine mammals when they grow to adults. Submerged grass meadows provide cover and food for a large number of organisms, including burrowing, bottom-dwelling invertebrates, diatoms and algae, herring that deposit eggs clusters on leaves, tiny crustaceans and fish that hide and feed among the blades, and larger fish and crabs. The protective structure attribute of eelgrass primarily is for smaller organisms and juvenile life history stages of fishes. Previous studies (Akins and Jefferson 1973) have reported that Coos Bay has 1,400 acres of lower intertidal and shallow subtidal flats covered by eelgrass meadows. The overall project would include enhancement of 6 acres of eelgrass habitat.

Although the dredging operation would not directly impact eelgrass, it would change physical conditions of the bottom, locally altering the bathymetry, and potentially altering the morphology and water currents. Benthic and epibenthic invertebrates that currently inhabit shallow intertidal and subtidal regions within the boundaries of the access channel would be removed with the dredged material. Ghost shrimp and sand shrimp (adults, juveniles, and larvae), amphipods, clams, Dungeness crab, and various fish species are important prey for harbor seals and other marine mammals. Therefore, the loss of invertebrates and vertebrates at the access channel would result in a reduction in fish food available to marine mammals in those areas affected by the construction activities in the short term.

A prior study has found that benthic communities in Coos Bay inhabiting mud substrates recovered to pre-dredging conditions in 4 weeks following typical channel dredging (McCauley et al. 1977). However, recovery in estuarine channel mud has been reported to be typically 6 to 8 months (Newell et al. 1998). In the lower Columbia River, McCabe et al. (1997, 1998) noted benthic organism recovery in 3 months. Complete recovery may take longer than 4 weeks, but likely still would be short term. However, because of the large quantity being dredged and increased depth, it may take a longer period relative to typical dredging. This likely would result in short-term adverse effects on the benthic community and potential food resources for marine mammals. Potential long-term effects of habitat modification would be offset by the enhancement of shallow water habitat, including eelgrass beds, in other portions of Coos Bay.

Aside from dredging, short-term, localized impacts on estuarine habitat would occur from construction at the Kentuck site and Eelgrass Mitigation site. A short-term increase in turbidity would occur into Kentuck Inlet and Coos Bay when the connection is re-established to the bay, and while the site equilibrates. As part of the eelgrass mitigation, a shallow-water hydraulic dredge is proposed to be used to lower areas that currently are too shallow to support eelgrass. Construction would occur during the ODFW in-water work window. Construction of the mitigation site would be likely to result in direct mortality of marine organisms through entrainment and temporarily would elevate turbidity levels from dredging. On completion of the restoration, the resulting habitat increase from the Eelgrass Mitigation site would provide overall benefits to marine organisms that use this habitat, by increasing the natural cover and forage production in Coos Bay. The increased habitat likely would offset the losses from the LNG Terminal site.

Shading from over-water structures reduces the amount of light available to phytoplankton and aquatic macrophytes. However, the area where shading LNG Terminal facilities would occur is intended for industrial uses and not for creation of new habitat. The general habitat in the slip's region would not be conducive for many marine resources because of depth and steep riprapped armored banks, and thus relatively few resources would be likely to use this newly created area. The water areas in the slip are being created from upland areas, and therefore shading of currently unshaded habitat would occur, and no net loss in productivity because of shading would occur. Construction at the TPP/US-101 intersection would result in temporary overwater structures placed over intertidal and shallow-water habitat, but they would be removed following completion of construction. Therefore, no permanent shading impacts would occur at that location.

9.2 Turbidity from Dredging and In-Water Construction

In-water construction activities are expected temporarily to increase concentrations of sediment and turbidity. Such increases would be localized and limited to the time required to complete each of the following project components within the ODFW in-water work window: Dredging; establishment of hydraulic connections to the Kentuck site for estuarine habitat mitigation; and creation of the Eelgrass Mitigation site.

Construction dredging of the access channel will result in temporary suspended sediment release similar to those that currently occur during maintenance dredging activities by USACE for the existing FNC. It is anticipated that the increases in turbidity will be temporary and localized, and will be taking place in areas where such increases will not depart substantially from ambient turbidity levels. The turbidity created by dredging is expected to be temporary, occurring only during and immediately after dredging activities take place within the authorized in-water work window.

Moffatt & Nichol performed turbidity plume dispersion modeling associated with dredging of the NRI and Eelgrass Mitigation site. The analysis also was conducted for the marine slip, access channel, and MOF. The results for these sites are discussed in the Turbidity Analysis Memo (Moffatt & Nichol 2017) and contractor's Dredging Plan (KBJ 2019). The modeling considered both hydraulic cutter suction and mechanical clamshell dredge methods. A number of simulation cases were assessed. The results of the modeling at the NRIs show that both dredge methods produce a similar turbidity plume that moves with the direction of the current (upstream or downstream). All plumes are localized to the point of dredging and disperse relatively quickly. At the Eelgrass Mitigation site, elevated turbidity (10 NTU above background) was determined to be localized.

When dredging in areas where the expected sediment is comprised of more than 20 percent fine-grained material, or is expected to degrade and release more than 20 percent fine-grained material, a turbidity meter shall be used to collect quantitative data measured in NTUs. In general, no more than a 10 percent increase in project-caused turbidity above background levels should occur with the implementation of BMPs; however, according to the Dredging Plan, if all reasonably available BMPs are implemented, turbidity exceedances of more than 10 percent above background are allowed for limited times depending on the severity of the increase (KBJ 2019).

Benthic and epibenthic biota would be directly and indirectly affected by sedimentation, turbidity, excavation of the TMBB, fill associated with the MOF, Access Channel dredging, the NRI Dredge Areas, and from other in-water construction activities. Temporary impacts on intertidal and deep subtidal habitats, including eelgrass communities, also would result from in-water construction, including the work bridge piling for the APCO sites access bridge, the Eelgrass Mitigation temporary dredge line, the Kentuck site, and the APCO 2 temporary dredge transfer line. Although both long and short-term losses of such habitat would adversely affect habitat for marine mammals, such impacts would be minor relative to the overall availability of estuarine habitat for marine mammals in Coos Bay. The Eelgrass Mitigation site, although requiring several years to develop, eventually would result in a long-term increase in habitat that would benefit the prey base for many marine mammals.

10. Anticipated Effects of Habitat Impacts on Marine Mammals

"The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved." (50 CFR Section 216.104[a][10])

Marine mammals may be affected by the temporary noise effects of project pile driving, described in Section 5, and the potential project-related impacts on the estuarine habitat of Coos Bay, as described in Section 9. The potential effects on habitat resulting from underwater noise would be temporary and minor and would not affect the prey base of harbor seals or other marine mammals.

Most species of marine mammals considered in this authorization request are infrequent to rare visitors to Coos Bay, and therefore would not be meaningfully affected by the habitat impacts of the construction activities, which would be extremely limited in scale when compared to the overall extent of resources available in the estuary. Harbor seals occur year-round in the Coos Bay estuary of Coos Bay, and therefore are more likely to be affected by the habitat impacts described in Section 9.

Roughly 40 acres of estuarine habitat would be modified by the construction of the LNG terminal and Ancillary Activities, representing a mere 0.3 percent of the approximately 13,700-acre estuary. About half of that affected area would be deepened by dredging and still would provide potential foraging areas for harbor seal. In addition, any losses of shallow water estuarine habitat would be offset through eelgrass mitigation and habitat restoration at the Kentuck site; therefore, no overall reduction in the extent, productivity, or quality of estuarine habitat available for harbor seal would occur.

Turbidity from construction is not expected to have any meaningful impacts on habitat for marine mammals, as described in Section 9.2. Similarly, implementation of estuarine conservation measures to protect listed fish species and Essential Fish Habitat (as designated by NMFS) would reduce potential effects from introduced invasive species. None of the effects on habitats in the Coos Bay estuary, including loss of eelgrass, intertidal habitats, or subtidal habitats by construction of the LNG Terminal or construction activities at the Ancillary Activities would significantly affect harbor seals or other marine mammals that occur in the Coos Bay estuary on a regular, seasonal or infrequent basis.

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11. Mitigation Measures

"The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance." (50 CFR Section 216.104[a][11])

JCEP has committed to minimizing impacts from project construction on marine resources. Pilings and sheet piles near the shoreline at the main LNG Terminal would be driven "in the dry" to avoid direct transfer of sound energy into the water column. The bulk of the LNG Terminal's slip would be excavated and dredged before being connected to the estuary, to reduce the duration and impact of that construction activity. Excavated materials would be used to restore the former Kentuck golf course to functional wetlands. Loss of eelgrass habitat would be offset by creation of new eelgrass habitat.

To reduce impacts on marine mammals specifically, JCEP will implement the following mitigation measures:

- Conduct the vast majority (over 90 percent) of the pile-driving activities at the LNG Terminal behind the earthen berm, which will prevent noise from emanating into the bay.
- Use a vibratory hammer to install the sheet piles at the MOF and the temporary mooring piles for the TMBB, TPP/US-101 and APCO sites.
- Before vibratory installation of piles at the LNG Terminal, pre-drill the soil to loosen and facilitate a more efficient installation and optimize vibratory driving.
- Implement a soft-start for impact hammer and vibratory pile-driving.
- Implement a monitoring plan that will include shutdown zones and monitoring areas, as described more fully in the Marine Mammal Monitoring Plan, provided in Appendix E. The key features of the monitoring plan will include:
    - Establishing shutdown zones around the work activity. Shutdown zones will be established that are equal to or larger than the Level A zone for all species. See Tables 11-1 and 11-2 below for monitoring and shutdown zones.
    - Work will be stopped whenever a marine mammal is about to enter the respective shutdown zone established for that species, so that no Level A take would occur.
    - Monitoring of Level B harassment zones. Work will be stopped if marine mammals other than those for which take has been authorized enter this area. For species with Level B take authorized, work will continue, and the take will be recorded up to the number authorized (Table 6-1 and 6-2., and their behavior while in the monitoring area will be documented.
- Implement hydroacoustic monitoring to verify that the monitoring zones are sufficient to prevent unauthorized take (See Appendix F).
- Perform all slip and access channel, dredging during lower abundance of the most susceptible fish life stage of the Pacific Coast Salmon Management Group and to avoid harbor seal pupping season, October 1 through February 15.

- Implement a water quality monitoring program during dredge operations, to assess the need for operational controls that assure turbidity levels remain within seasonal permitted limits.
- Implement vessel operational controls to assure compliance with applicable water quality standards.
- For the LNG facility, implement a site-specific Spill Prevention and Containment Control Plan to minimize the potential for accidental releases of hazardous materials.
- Provide low-intensity lights on docks and consult on final design, to best assure that lighting minimizes conditions potentially resulting in fish attraction or predation.
- To the extent possible, use a vibratory hammer to avoid adverse in-water noise effects. Minimize the use of impact driving.
- Use sound attenuation measures (such as a bubble curtain or cofferdam) to minimize adverse in-water noise effects from pile driving with an impact hammer during in-water pile driving.
- Conduct much of the slip excavation behind the berm, to reduce effects of turbidity and sedimentation on the waters of Coos Bay.
- Implement Hydrostatic Testing Plan methods to equipment use and cleaning, to reduce invasive species spread or entry to the estuary.
- Implement the eelgrass mitigation west of the Southwest Oregon Regional Airport, to help offset potential impacts to the productivity of prey species in the estuary since eelgrass beds are important rearing grounds for fish and invertebrates.

Table 11-1 Year 1 Construction Season Level B Harassment and Shutdown Zones for LNG Terminal in Meters[1]

Species	Vibratory Pile-Driving Sheet Piles at MOF/West Berth wall and TMBB Mooring Piles[2]
Level B Harassment Zone	
All Species with Take Authorized	1,920
Shutdown Zone	
Pacific Harbor Seal	10
Northern Elephant Seal	10
California Sea Lion	10
Stellar Sea Lion	10
Gray Whale	10
Killer Whale	10
Harbor Porpoise	10

[1] Shutdown Zone is applicable for all pile-driving and extraction activities for all marine mammal species groups. Exact distances for each hearing group for each activity type are all within 10 meters.

[2] Level B monitoring zone is limited by the distance to the shorelines within the bay and feasible line of site for a MMO. For example, the shoreline at the TPP/US-101 location limits the extent of the Level B zone to 1,500 meters or less. For purposes of counting take, observations made within 2000 meters will be used to determine an animal density for the day and then take will be extrapolated out to the full Level B zone.

Table 11-2 Year 1 Construction Season Level B Harassment and Shutdown Zones for Ancillary Activities in Meters[1]

Species	Impact Pile Driving		Vibratory Pile-Driving	
	Timber Piles at TPP/US-101	Pipe Piles at TPP/US-101	Pipe Piles, Timber Piles and Sheet Piles at TPP/US-101	Pipe Piles at APCO,
Level B Harassment Zone				
All Species with Take Authorized	50	350	7,000[2]	7,000[2]
Shutdown Zone				
Pacific Harbor Seal	30	70	10	10
Northern Elephant Seal	30	70	10	10
California Sea Lion	10	10	10	10
Stellar Sea Lion	10	10	10	10
Gray Whale	60	140	25	30
Killer Whale	10	10	10	10
Harbor Porpoise	60	140	25	30

[1] Shutdown Zone is applicable for all pile-driving and extraction activities for all marine mammal species groups. Exact distances for each hearing group for each activity type are all within 10 meters.

[2] Level B monitoring zone is limited by the distance to the shorelines within the bay and feasible line of site for a MMO. For example, the shoreline at the TPP/US-101 location limits the extent of the Level B zone to 1,500 meters or less. For purposes of counting take, observations made within 2000 meters will be used to determine an animal density for the day and then take will be extrapolated out to the full Level B zone.

12. Arctic Subsistence Plan of Cooperation

“Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a ‘plan of cooperation’ or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.” (50 CFR Section 216.104[a][12])

Not applicable because the project would be constructed in Oregon.

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13. Monitoring and Reporting

"The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding. Guidelines for developing a site-specific monitoring plan may be obtained by writing to the Director, Office of Protected Resources." (50 CFR Section 216.104[a][13])

JCEP's Marine Mammal Monitoring Plan includes five components: 1) conduct a preconstruction survey; 2) monitor marine mammal occurrence near the project site during construction; 3) enforce shutdown zones (as described in Section 11) for marine mammals ; 4) record observations of marine mammals in the observable portions[3] of the Level B harassment zones, including movement and behavior of animals; and 5) report the results of the preconstruction survey and the construction monitoring, including take numbers. Each of these components is discussed in detail in the associated Marine Mammal Monitoring Plan, provided in Appendix E.

In addition, a Hydroacoustic Monitoring Plan would be developed in coordination with NMFS. This plan would be designed to verify that underwater noise thresholds are not exceeded over distances greater than predicted in the IHA. A representative subset of each pile type and installation method would be monitored. The results of this hydroacoustic monitoring also may be used, in coordination with and approval by NMFS, to reduce monitoring zones during construction.

[3] Generally speaking, the protected species observers may be able to observe larger cetaceans that are within 2,000 meters of pile driving, and smaller marine mammals within 500 to 1,000 meters, depending on weather conditions. Recording all marine mammal activity in the entirety of the vibratory driving Level B zones is not practicable.

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14. Suggested Means of Coordination

"Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects." (50 CFR Section 216.104[a][14])

JCEP would support the ongoing efforts of local whale monitoring groups in conducting seasonal counts of migrating gray whales passing the Coos Bay area. This increased documentation of the use of the area offshore of the entrance to the Coos Bay estuary would help inform measures that may be implemented to better protect marine mammals transiting the area from being affected by increasing shipping along the Oregon coast. JCEP would be in close contact with the Oregon Institute of Marine Biology (OIMB), to manage, understand, and communicate information about environmental impacts related to construction activities. Ongoing communication with OIMB would be implemented by JCEP during construction, to discuss occurrences of extralimital species, to better inform the marine mammal monitoring teams. Marine mammal sightings and recordation could be made available to interested parties, to further assess the species in the area, based on the lack of recent, site-specific data. In addition to the marine mammal monitoring reporting (described in Section 13), JCEP also would provide hydroacoustic monitoring reporting to NMFS, ODFW, and other agencies as requested, to further the understanding and data available regarding the generation and transmission of underwater noise during pile driving, particularly regarding the driving of piles into land along the water's edge, for which little data currently are available.

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Appendices

Appendix A: Jordan Cove Marine Mammal Surveys Field Reports 2017 and 2018

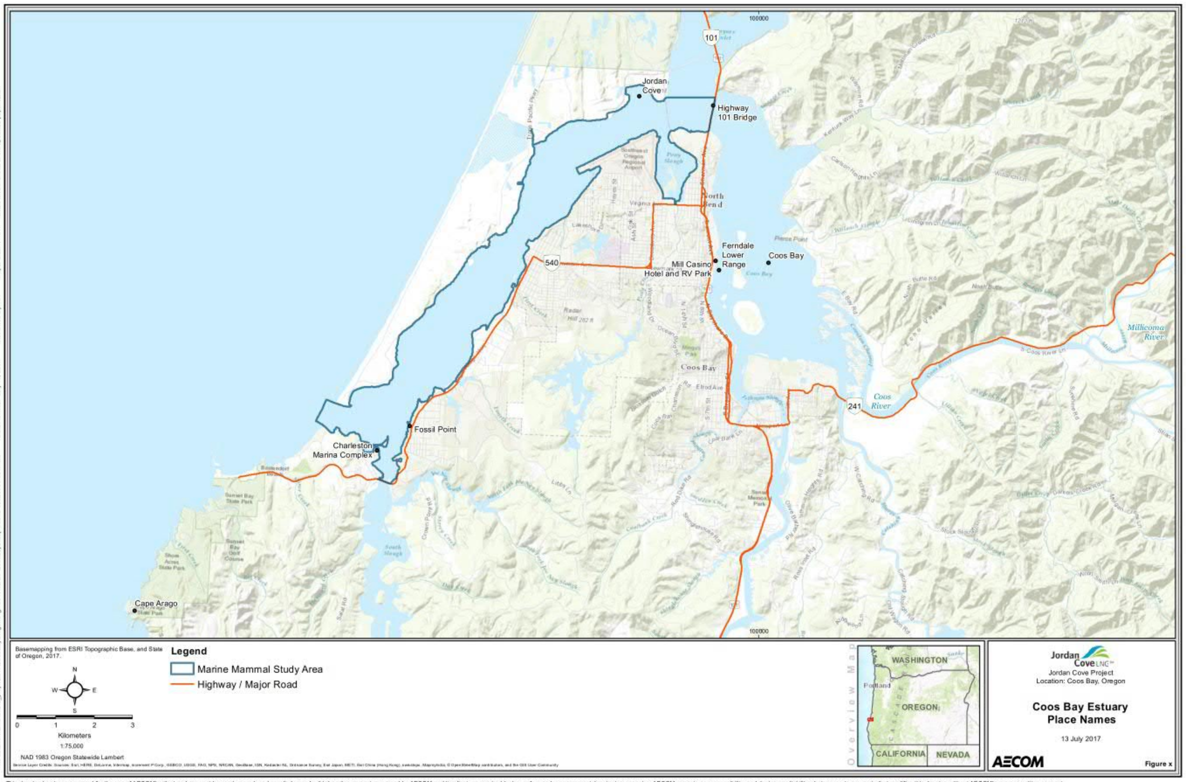
Jordan Cove Marine Mammal Surveys Field Report

July 14, 2017

Introduction

A marine scientific assessment was conducted in May 2017 to improve the knowledge of the use of the Coos Bay estuary by marine mammals. These data will be important for the development of a comprehensive marine mammal management plan related to the construction and operation of the proposed Liquefied Natural Gas (LNG) terminal at Jordan Cove (Figure 1). Existing relevant marine mammal data were limited to two known harbor seal haul-out sites on Clam Island and Pigeon Point. The goal of the marine survey was to add to the existing data through scientific assessment and collection of local knowledge. The scientific assessment was conducted using a Distance-based line transect protocol, with two sets of survey days timed to sample during successive neap and spring tides, while the local knowledge was collected through informal discussions. The marine survey was conducted from a small vessel with a zoologist and captain with visual data recorded. Marine mammal observational data were collected during systematic surveys and on an opportunistic basis while transiting to and from the transect survey lines. Additional marine mammal opportunistic data were also collected from land, and through conversations with experienced local residents. In addition to the observational data, underwater acoustic data were also collected with a calibrated hydrophone to detect submerged marine mammals as well as the ambient underwater acoustic environment. Jordan Cove recognizes that the short duration of the field effort was not sufficient to provide comprehensive insight into the marine mammal use of the Coos Bay estuary. However, the field work is providing a much greater understanding of the marine mammal species presence, relative abundance and distribution than the currently existing data permitted. This information will allow for a more targeted approach to the development of a marine mammal management plan for the project with a more species-specific approach to mitigation and conservation actions, than would have been possible otherwise.

Figure 1. Marine Mammal Study Area and Coos Bay Place Names



Objectives

The objectives of the marine mammal assessment were to:

1) Identify the marine mammal species that were using the Coos Bay estuary.
2) Determine the relative abundance and distribution of the marine mammal species within the Coos Bay estuary study area.
3) Document the habitats and behaviors of the observed marine mammals within the study area.
4) Collect local knowledge of marine mammals in the Coos Bay estuary and nearby Pacific waters.

Methods

Systematic visual observations of marine mammals were made from a small vessel survey conducted in the navigable waters of the Coos Bay estuary using a Distance-based protocol. The study area was defined by the Highway 101 Bridge to the entrance of the estuary, and included only the navigable waters of the estuary (Figure 1). The study area encompassed 15.09 square kilometres (km^2). A random number generator was used to determine the start location each day, with transect lines then conducted sequentially as weather conditions allowed. Observations were made by two Marine Mammal Observers (MMOs) with extensive experience (Appendix A) in the coastal marine mammals of the northeast Pacific Ocean. The forward 180° was actively visually monitored along the course of each transect line by both observers. The transect lines were conducted in closing mode, meaning the transect line effort was stopped to collect additional data as required, including photographs and behavioral observations. After additional data were collected, the team returned to the location on the transect lines where the effort had been discontinued, and resumed the on-effort systematic data collection. These interruptions were kept to a minimum so that the majority of the time was spent collecting the systematic line transect data. The line transect effort was commenced in good visibility and sea states of Beaufort 0-2 at speeds of 10-12 knots. Data collection for each sighting included species, distance from research vessel, radial angle, group size, location, and behavior. Data were recorded on waterproof data sheets.

Acoustic data were also collected throughout the study area. All acoustic data were collected using a CRT-CR1 calibrated hydrophone, and SpectraPlus software. Ancillary data were recorded in a waterproof notebook and included the time the acoustic recording commenced, the location, sea state, and anthropogenic activity or biological observations observed during the recording period. Acoustic data were collected secondarily to the line transect data, as the primary objectives of the study were based on visual data collection. During acoustic data collection, the vessel engine was turned off, and except for navigational safety so was the depth sounder. This was done to minimize noise associated with the vessel and on-board equipment.

Local knowledge was collected through informal discussions with local residents. Line transect and acoustic data collection were prioritized over the informal data collection. The discussions included details on marine mammal species not frequently observed in the Coos Bay estuary, as well as the regular observations of marine mammals using the contiguous open Pacific waters.

Results

Line Transect Effort

All marine work was conducted aboard the R/V Pugettia from the Oregon Institute of Marine Biology. Systematic line transects were conducted on 4, 5, 9, and 10 May 2017 (Table 1). The total effort consisted of 1179 minutes (19.7 hours) of on-the-water effort with a total of 172.2 nautical miles (nm) (318.9 km) travelled (Table 1). A total of 42 transect lines were completed which totaled 111.5 nm (60.2 km) while on-effort in sea states Beaufort 0-3. All transect lines, except the last line of the survey on 10 May 2017 were commenced in sea states Beaufort 0-2. Effort was conducted throughout the daylight hours (Table 1), but was limited by the weather conditions including morning fog and afternoon winds.

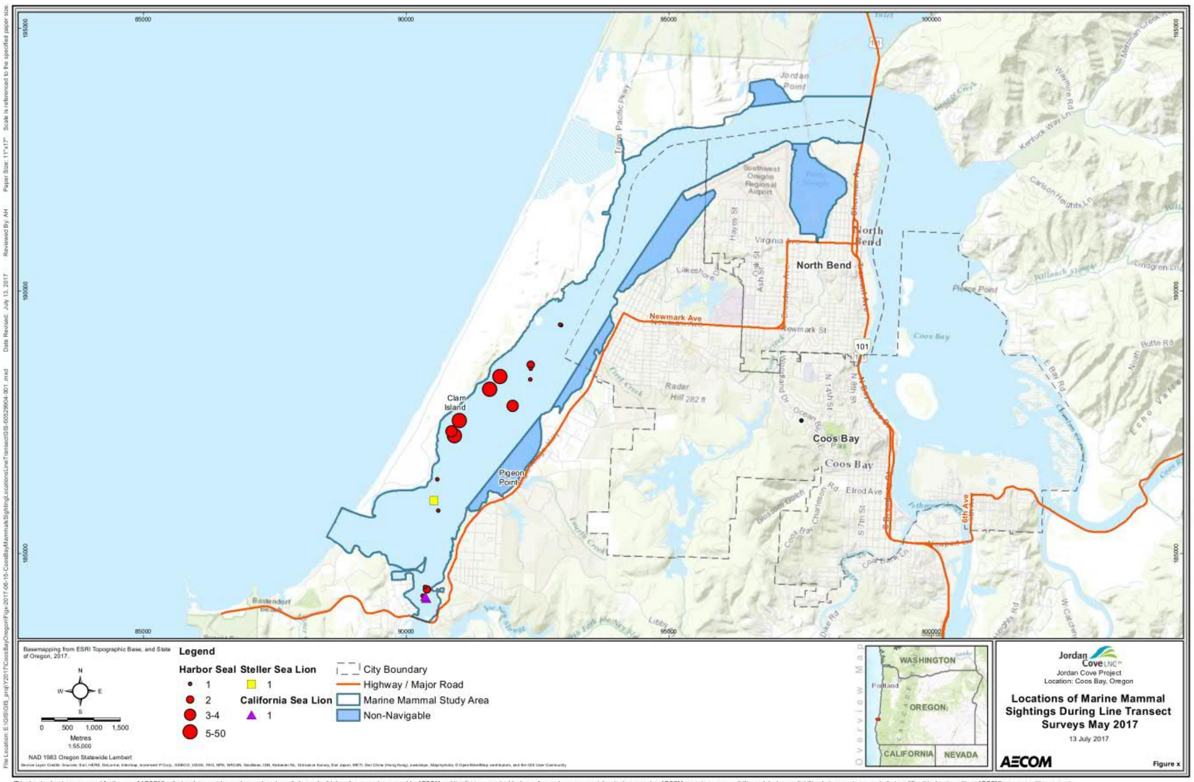
Table 1. Field surveys daily effort

Date	Departure Time	Return Time	Total Time, mins	Total Distance, nm
4-May-17	920	1000	40	10.2
4-May-17	1157	1430	153	34.6
5-May-17	918	1229	191	18.3
5-May-17	1500	1810	190	26.5
9-May-17	827	1234	288	29.5
10-May-17	846	1215	209	22.1
10-May-17	1400	1548	108	22.1
Total			1179	172.2

Line Transect Observations

Three species of marine mammal were identified during the on-effort component of the line transect surveys. Harbor seals (*Phoca vitulina*), Steller sea lions (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*) were observed over the four survey days while on-effort (Figure 2, Table 2), with most sightings being harbor seals. Group sizes ranged from 1 to an estimated 100 animals, with sightings of pinnipeds both in the water and hauled out on land (Table 2). All of the large group sizes (> 30) of harbor seals were hauled out. In order to accurately represent the field observations, the sighting of the estimated 100 harbor seals was not included in Figure 2 because it was considered likely to be the same animals hauled out on Clam Island from day to day but observed in different spatial groupings.

Figure 2. Marine mammals observed during systematic line transect surveys



The species specific sample sizes were insufficient to complete statistical estimates of species density or abundance. However, during the line transect surveys, there was an estimated 374 harbor seals counted in 19 groups (Table 3). The sightings of sea lions were much lower with two California sea lions and only one Steller sea lion observed during the systematic surveys.

Table 2. Marine mammals observed during line transect surveys

Date	Species	Number	Time Observed	Behavior
4-May-17	Harbor Seal	40-50	1438	hauled out
4-May-17	Harbor Seal	1	1439	swimming
4-May-17	Harbor Seal	30	1441	hauled out
4-May-17	Harbor Seal	3	1442	hauled out
5-May-17	California Sea Lion	1	0932	swimming
5-May-17	Harbor Seal	2	0933	swimming
5-May-17	Steller Sea Lion	1	0941	swimming
5-May-17	Harbor Seal	30	1300	hauled out
9-May-17	California Sea Lion	1	1006	hauled out
9-May-17	Harbor Seal	1	1016	swimming
9-May-17	Harbor Seal	1	1147	swimming
9-May-17	Harbor Seal	50	1147	hauled out
9-May-17	Harbor Seal	50	1147	hauled out
9-May-17	Harbor Seal	50	1147	hauled out
9-May-17	Harbor Seal	1	1149	floating
10-May-17	Harbor Seal	1	0914	swimming
10-May-17	Harbor Seal	1	0929	swimming
10-May-17	Harbor Seal	2	0930	swimming
10-May-17	Harbor Seal	100	1128	hauled out
10-May-17	Harbor Seal	3-4	1131	hauled out
10-May-17	Harbor Seal	1	1159	swimming
10-May-17	Harbor Seal	1	1200	swimming

As the total on-effort mileage was 60.2 km, this yields relative densities as follows:

- Harbor seal: 6.20/km
- California sea lion: 0.03/km
- Steller sea lion: 0.02/km

In terms of the number of the number of groups observed, there was nearly an equal number of harbor seals groups hauled out on land (*n*=9) and floating or swimming in the water (*n*=10) (Tables 2 and 3). There was an equal number for California sea lions hauled out (*n*=1) and on land (*n*=1), but only a single sighting of a Steller sea lion in the water, so no comparison could not be made regarding habitat type use (Tables 2 and 3).

Table 3. Marine mammal behavior classifications

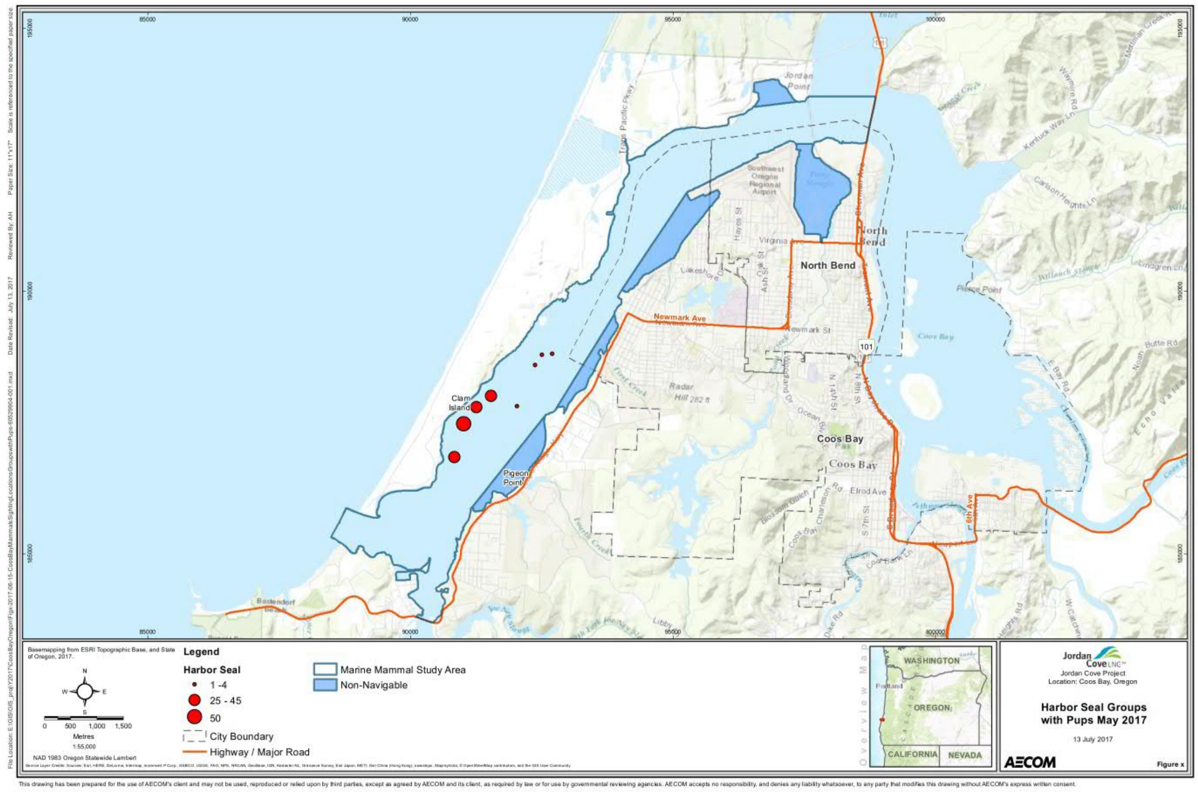
Species	Number of Groups In The Water	Number of Groups On Land
Harbor Seal	10	9
California Sea Lion	1	1
Steller Sea Lion	1	0

In terms of the number of groups sighted with and without pups, harbor seals were observed in nearly equal numbers (Table 4). No California or Steller sea lion pups were observed during the on-effort component of the line transect surveys (Table 4). Of the groups of harbor seals with pups observed, all but one were hauled out, with all large groups of harbor seals with pups at Clam Island where nursing behavior was observed (Figure 3, Photograph 1). Harbor seal vocalizations in air were audible during observations of mother-pup pairs. The hauled out California sea lion was observed while on-effort at the Charleston Marina Complex (Figure 1, Photograph 2).

Table 4. Marine mammal pups

Species	Number of Sightings with Pups	Number of Sightings without Pups
Harbor Seal	9	10
California Sea Lion	0	2
Steller Sea Lion	0	1

Figure 3. Harbor seal groups with pups



Photograph 1. Harbor seal mother-pup pairs hauled out at Clam Island

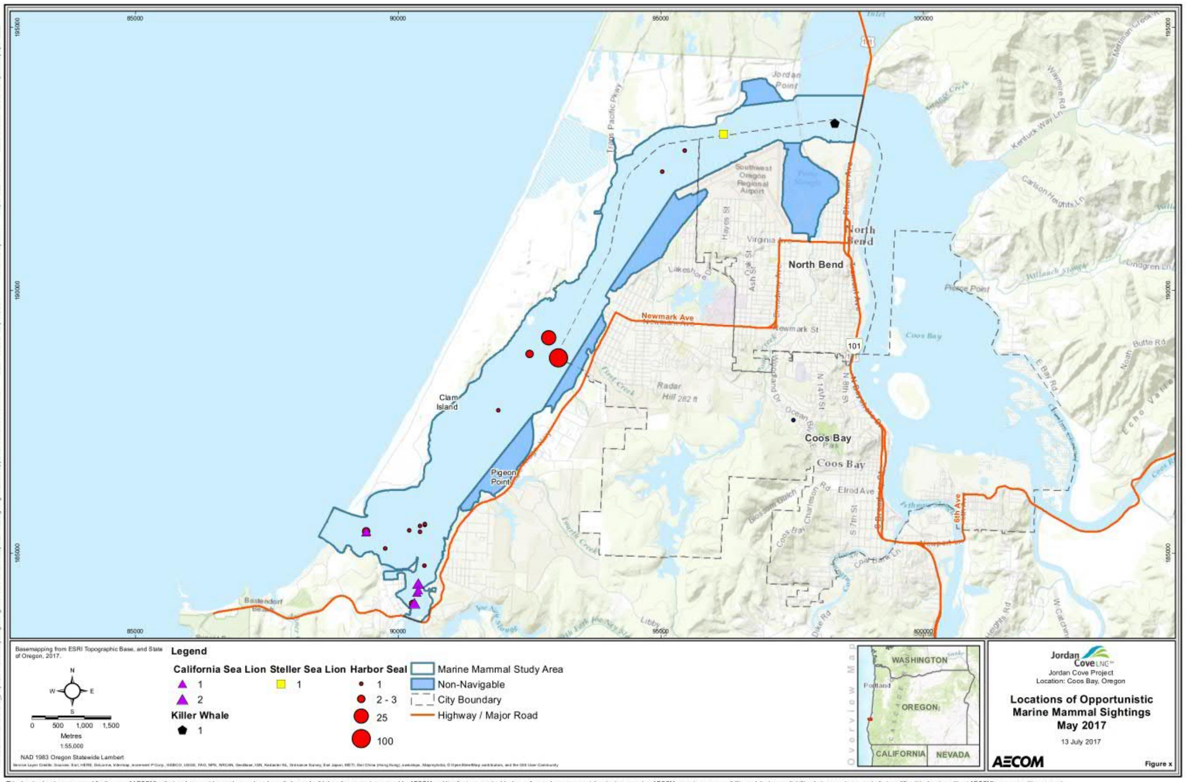
Photograph 2. California sea lion hauled out on float in the Charleston Marina Complex

Opportunistic Observations

In addition, to the systematic line transect data, opportunistic data were also recorded. There were 24 sightings of varying group sizes of harbor seals, California sea lions, Steller sea lions and transient killer whales (*Orcinus orca*) distributed throughout the study area (Figure 4). Harbor seals were the most often and abundant marine mammal species opportunistically sighted during the marine surveys (Table 5). No pups or calves were observed except for harbor seals, with two large groups (n=25, n=100) hauled out on tidal sand bars with nursing pups (Table 5).

The transient killer whales were observed during the afternoon of 5 May 2017 (Photograph 3). A focal follow was conducted with the male and female transient killer whale from 1420 - 1744 through the estuary waters northwards past Jordan Cove to the Highway 101 Bridge limit of the study area (Figure 1). A successful predation event was documented, though the species consumed was not able to be determined.

Figure 4. Opportunistic marine mammal sightings in the study area



Photograph 3. Transient killer whales near Jordan Cove

Table 5. Opportunistic Data Summary

	Number of Groups	Number of Animals	Pups/Calves
Harbor Seal	16	144	Yes
California Sea Lion	6	8	No
Steller Sea Lion	1	1	No
Killer Whale	1	2	No

Acoustic Recordings

Twenty acoustic recordings were made over 4, 5, 9, 10 May 2017 during the field efforts for the line transect surveys. Interval recordings ranging from 0.93 – 10.34 minutes were made, with 14 of the acoustic samples greater than 5 minutes in length. Acoustic samples were recorded for the maximum time up to 10 minutes, but were limited by navigational safety due to vessel drift. In total, 2.5 hours of ambient underwater acoustic recordings were collected.

While no detailed acoustic analyses were conducted, the relative ambient noise levels were calculated for each acoustic sample throughout the study area. The root mean square (rms) values show the variation in the underwater acoustic environment that was present during the sampling period (Table 6). Acoustic sample locations were recorded, but were generally described based on the relative location or presence of identifiable landmark (i.e. Highway 101 Bridge) (Table 6).

Table 6. Ambient average noise levels throughout Coos Bay estuary study area.

Date	General Area Description	rms dB re1 uPa
4-May-17	Lower Coos Bay estuary	123.3
4-May-17	Lower Coos Bay estuary	123.8
4-May-17	Near Highway 101 Bridge	125.0
4-May-17	Near Roseburg Forest Products Chip Terminal	169.7
4-May-17	Near Jordan Cove	109.6
5-May-17	Near Jordan Cove	123.7
5-May-17	Near Clam Island	125.6
5-May-17	Near Roseburg Forest Products Chip Terminal	130.8
5-May-17	Near North Bend Airport	126.3
5-May-17	Central Coos Bay Estuary	123.8
5-May-17	Central Coos Bay Estuary	124.1
5-May-17	Central Coos Bay Estuary	129.7
9-May-17	Lower Coos Bay estuary	126.4
9-May-17	Lower Coos Bay estuary	128.7
9-May-17	Near Highway 101 Bridge	121.6
10-May-17	Near Roseburg Forest Products Chip Terminal	126.2
10-May-17	Lower Coos Bay estuary	124.4
10-May-17	Near Highway 101 Bridge	123.4
10-May-17	Near Roseburg Forest Products Chip Terminal	123.7
10-May-17	Near Jordan Cove	125.1

The ambient noise levels ranged from 109.6 – 169.7 rms dB re 1µPa (Table 6), with the highest levels recorded during active loading of a container vessel at the Roseburg Forest Products Chip Terminal on 4 May 2017 in Jordan Cove. The lowest ambient noise levels were recorded on 4 May 2017, also near Jordan Cove, with a calculated rms noise level of 109.6 dB re 1µPa (Table 6).

The acoustic recordings were reviewed for potential marine mammal vocalizations and a brief call was recorded during the transient killer whale predation event recorded on 5 May 2017. While not confirmed, the call is very likely to be one of the transient killer whales engaged in active predation. Other interesting, but unidentified low frequency sounds (~70 – 173 Hz) were recorded on 9 May 2017 in the lower estuary region. These intermittent sounds have not yet been identified. Though several recordings were made near harbor seal mother-pup pairs, no underwater calls were recorded, though in-air calls from hauled out animals were audible to the field team.

Local Information
In addition to the systematic and opportunistic data collected during the marine surveys, local knowledge was also documented to contribute to reducing the seasonal data gaps. This provided information on other marine mammal species including harbor porpoise (*Phocoena phocoena*), grey whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), blue whales (*Balaenoptera musculus*), and northern elephant seals (*Mirounga angustirostris*), as well as for salmon (*Oncorhynchus sp.)* and herring (*Clupea pallasii*).

The harbor porpoise, grey and humpback whales were described as using the waters within a few miles of shore, and also occasionally coming into the waters of the lower estuary on an inter-annual basis. Harbor porpoise were described as occurring in the lower estuary, when herring or perhaps other forage fish were more abundant. The blue whales and northern elephant seals were described as using the waters between Cape Arago and the entrance to the Coos Bay estuary (Figure 1). Since 1993, northern elephant seals have been known to pup at Shell Island off Cape Arago. Blue whales were described as preferring the open waters at about the 50 fathom (91 meter) depth, and that their occurrence was similar to that of the salmon in the late summer/early fall.

Local knowledge also provided greater details on the use of the area by the species observed during the systematic surveys including that the nearest rookery for Steller sea lions is at Orford Reef, approximately 50 miles south of the estuary (off Port Orford), and that the current survey was well timed to capture the harbor seal pupping season, which occurs annually from late April to June. Harbor seals were described as using the Coos Bay estuary from the entrance to at least the junction between the Millicoma and Coos Rivers (Figure 1) which was described locally as "the Forks". It was thought that perhaps the animals using that region were resident due to the reliability of the sightings in the water and hauled out on the sandy beach. It was also described that the transient killer whales observed on 5 May 2017 continued past the Highway 101 Bridge at least as far as the Ferndale Lower Range as the animals were observed from The Mill Casino Hotel and RV Park at Coos Bay (Figure 1).

Local knowledge described three ecological events that were considered important to the Coos Bay estuary:

1. harbor seal pupping,
2. salmon migrations, and
3. herring spawning.

The salmon migrations were described as an important factor related to the changes in seasonal abundance of sea lions, with the high season occurring during the late summer to early fall when sea lions numbers were said to increase markedly throughout the estuary. The herring spawn was described as occurring from mid-February to early March, with Fossil Point (Figure 1) specifically identified as a spawning site. This was identified as the time when harbor porpoise would most likely be present in the estuary, with habitat use extending from the lower estuary to near Fossil Point. However, it was also stated that no directed studies had been undertaken for harbor porpoise, so the geographical extent of the use of the estuary was uncertain and could extend farther into the estuary than Fossil Point. It was suggested that replicate surveys be conducted in August/September and February/March to capture the seasonality of the marine mammals in the estuary relevant to these events.

Summary

Jordan Cove undertook a comprehensive marine mammal survey throughout the outer half of the Coos Bay estuary from the Highway 101 Bridge to the western entrance to Coos Bay over four days in May 2017. The survey included line transect, opportunistic, acoustic and local knowledge data collection. The field work was conducted by experienced MMOs in daylight hours with good visibility, spanning successive neap and spring tides. The results of the survey indicated that marine mammals were found throughout the entire study area. Harbor seals, Steller sea lions, California sea lions and transient killer whales were documented in the estuary, with a confirmed killer whale predation event visually and acoustically documented. Local knowledge indicated that humpback whales, grey whales and harbor porpoise occasionally enter Coos Bay estuary with seasonal and inter-annual variation in frequency and numbers. Local knowledge also indicated that northern elephant seals and blue whales use the Pacific waters just westward of the entrance to Coos Bay, sometimes within sight of the shoreline. In summary, the multifaceted approach to data collection utilizing systematic line transect surveys, supplemented with opportunistic data and local knowledge about marine mammals greatly enhanced the available information on the marine mammal species, presence and use of the Coos Bay estuary. The marine survey also provided acoustic snapshots of the underwater ambient environment during the field study period. Collectively, these data provide a more solid foundation for the development of the marine mammal management plan for the construction and operation of the proposed LNG terminal at Jordan Cove. These results also can be used to make a contribution to the existing local knowledge of the marine mammal use of the Coos Bay estuary.

Appendix A – Field Crew Qualifications

The field crew were evaluated prior to participation in the field surveys for marine mammals. Due to the limited timeframe to collect data, only experienced field crew were considered. This was implemented to maximize the data opportunities from the field effort. The criteria used to evaluate the field crew was defined as follows:

- Visual acuity in both eyes (correction was permissible) sufficient to discern moving or stationary targets at varying distances (e.g. haul-outs and cryptic species).
- Demonstrable experience in marine mammal field research – this could include advanced education in biological science, wildlife management, marine mammalogy or related fields, or participation in academic research.
- Coastal marine experience with Northeast Pacific marine mammals and scientific data collection.
- Experience with marine mammal hydro-acoustics and hydrophone equipment.
- Experience and ability to conduct field observations and collect data according to assigned protocols.
- Experience or training in the field identification of cetaceans and pinnipeds.
- Experience in small vessel operation. Professional operation was preferred with good working knowledge of vessel equipment/machinery and navigation.
- Valid Oregon State Boaters license.
- Writing skills sufficient to prepare a report of observations, including the number, species, behaviour, and location of marine mammals.
- Ability to communicate orally, by radio or in person, with project personnel to provide real time information on marine mammals observed in the area, as needed.
- Demonstrable experience with collection of local knowledge.
- Prior participation in small vessel line transect surveys for marine mammals.

Jordan Cove Marine Mammal Surveys Field Report

December 18, 2018

Introduction

AECOM was hired by Jordan Cove to conduct a marine scientific assessment in November and December 2018 to improve the knowledge of the marine mammal species presence, relative density and habitat use in the Coos Bay estuary during the non-pupping/weaning season for harbor seals (*Phoca vitulina*). This survey was the second in a set of marine mammal assessments for this region. The first study supporting the Jordan Cove Liquefied Natural Gas (LNG) terminal development was conducted in May 2017 and was timed to coincide with the harbor seal pupping and weaning season, when pups are identifiable due to their small size and seal numbers in the Coos Bay estuary are increasing to the summer maximum (Graybill 1981). Collectively these seasonal data are important for the assessment of potential effects on marine mammals of the in-water and near-shore construction associated with the Jordan Cove LNG Project. Further, these data will contribute to the comprehensive marine mammal management plan related to the construction and operations of the proposed Project (Figure 1).

Prior to these surveys, the primary marine mammal data relevant to the Coos Bay estuary were from a Master's thesis (Graybill 1981). Other researchers have provided general information about seals in Coos Bay particularly for their use of the two known harbor seal haul-out sites on Clam Island (also referred to as North Spit) and near Pigeon Point (Pearson 1969, Brown 1988, BLM 2006, Wright 2013, 2016). The goal of our seasonal marine surveys was to add to these existing data through scientific assessment and collection of local knowledge. The scientific assessment was conducted using three techniques: a standardized line transect survey, underwater acoustic monitoring and aerial drone photography. The line transect survey employed a Distance-based protocol, while the aerial photography involved the use of a professional photography service (PacWest Drone Services) from Coos Bay, Oregon. The scientific survey was conducted from a small vessel with a zoologist and captain with visual and acoustic data recorded. Marine mammal observational data were collected both during systematic surveys and on an opportunistic basis while transiting to and from the transect survey lines. The acoustic data were collected with a calibrated hydrophone to characterize the ambient underwater acoustic environment. The collection of local knowledge was completed in May 2017 through informal discussions with local residents and researchers. Jordan Cove recognizes that the short duration of the two field efforts was not sufficient to provide comprehensive insight into the marine mammal use of the Coos Bay estuary throughout the year. However, this field work broadened the existing knowledge from that which was previously available, and provided a more solid foundation from which to gauge the marine mammal species seasonal presence, relative density and distribution in the Coos Bay estuary study area.

Figure 1. Marine Mammal Study Area and Coos Bay Place Names

Objectives

The objectives of the November 2018 marine mammal assessment were to:

1) Identify marine mammal species using the Coos Bay estuary during the non-pupping/weaning season for harbor seals.
2) Determine the sighting rate, relative density and distribution of the marine mammal species within the Coos Bay estuary study area during this time period.
3) Document the habitats and behaviors of the observed marine mammals within the study area.
4) Collect underwater acoustic data to characterize the ambient sound levels.

Methods

In order to provide consistent and comparable data, the marine survey methods used in November 2018, were the same as those used in May 2017. The systematic visual observations of marine mammals were made during a small vessel line transect survey using a Distance-based line transect protocol. The study area extended from the Highway 101 Bridge to the seaward entrance to the Coos Bay estuary (Figure 1). Parallel transect lines were oriented in a north-south direction and included only the navigable waters of the estuary, which varied by tide height due to the shallow bathymetry of the region. The study area encompassed 15.09 square kilometers (km^2).

The daily transect start locations were selected using a random number generator in Microsoft Excel. The transect lines were then conducted sequentially as weather conditions allowed. Observations were made by two Marine Mammal Observers (MMOs) with extensive experience with northeast Pacific Ocean coastal marine mammals and line transect survey protocols. In order to ensure consistency and comparability of data, the same MMOs were used in the 2017 and 2018 marine surveys.

In both marine surveys, the forward 180° was actively visually monitored along the course of each transect line by both observers. The transect lines were conducted in closing mode, meaning the transect line effort was stopped to collect additional data as required, including photographs and behavioral observations. After additional data were collected, the team returned to the location on the transect lines where the effort had been discontinued, and resumed the on-effort systematic data collection. These interruptions were kept to a minimum so that the majority of the time was spent collecting the systematic line transect data. The line transect effort was commenced in good visibility and sea states of Beaufort 1-2 at an average speed of 6.0 nautical miles per hour (knots). Data collection for each sighting included species, distance from research vessel, radial angle, group size, location, and behavior. Data were recorded on waterproof data sheets.

The aerial photography of hauled out harbor seals was initially conducted at three sites: Clam Island, near Pigeon Point and near Coos Harbor. However, aerial photography at Coos Harbor was discontinued after the first two days of flights because harbor seals were not observed and local knowledge indicated that use of that potential haul-out by seals would be rare. This change allowed the aerial survey to focus on the two known sites within the study area: Clam Island and near Pigeon Point (Figure 1). Aerial photographic data were collected on 19, 20 and 26, November 2018 and 6 December 2018. These data were collected by PacWest Drone Services, based in Coos Bay, Oregon. The resulting photographs were then independently reviewed twice for harbor seal enumeration using Microsoft Office Power Point.

Acoustic data were collected throughout the study area. All acoustic data were collected using a CRT-CR1 calibrated hydrophone. Acoustic data were processed in SpectraPlus. Ancillary data were recorded in a waterproof notebook and included the time the acoustic recording commenced, the location, sea state, and anthropogenic activity or biological observations observed during the recording period. Acoustic data were collected secondarily to the line transect data, as the primary objectives of the study were based on visual data collection. During acoustic data collection, the vessel engine and depth sounder were turned off for the duration of the recording. This procedure was followed to eliminate the vessel-generated noise and accurately characterise the underwater acoustic environment.

Results

Line Transect Effort

All marine survey work was conducted aboard the R/V Pugettia from the Oregon Institute of Marine Biology. Systematic line transects were conducted on 26, 27, and 28 November 2018 (Table 1). The total marine effort consisted of 970 minutes (16.2 hours) of on-the-water effort with a total of 125.4 nautical miles (nm) (232.2 km) travelled (Table 1). A total of 50 transect lines were completed which totaled 28.1 nm (52.0 km) while on-effort in sea states Beaufort 1-2. Though sea states exceeded Beaufort 3 periodically throughout the study period, the effort was discontinued during this time as the probability of detection of small marine mammals was reduced. Effort was conducted throughout the daylight hours only (Table 1), but was limited by the weather conditions which included high winds, heavy rain and sea states greater than Beaufort 3.

Table 1. Field surveys daily effort.

Date	Departure Time	Return Time	Total Hours	Total mins	Total Time, mins	Daily Total Distance, nm
26-Nov-18	910	1300	3	14	194	--
26-Nov-18	1400	1641	2	34	154	40.4
27-Nov-18	0835	1210	3	35	215	--
27-Nov-18	1310	1500	1	40	100	50.0
28-Nov-18	0825	1320	5	7	307	35.0
Total	--	--	14	130	970	125.4

Line Transect Observations

Only one species of marine mammal was observed during the November 2018 line transect surveys. Harbor seals were seen on two of the three survey days while on-effort (Figure 2, Table 2). There were few sightings during the line transect surveys (n=5) (Table 2). All seals observed during the line transects were of single animals (n=4) or a single pair of animals (Figure 2, Table 2). All sightings were of animals in the water, either swimming or floating at the sea surface (Table 2, Photograph 1). It is possible that some animals were re-sighted between days, as no effort was made to identify individuals, but given the low number of sightings compared to the aerial photography (see below) this seems unlikely. There were no identifiable pups sighted during the line transect surveys.

As a result of the low number of harbor seal sightings during the line transect effort, reliable statistical estimates of species density (i.e. number/km^2) or abundance (i.e. total number) within the Study Area could not be accurately calculated. However, for comparison with the May 2017 data, the number of seals observed could be quantified by the effort expended. Since the total on-effort mileage was 52.0 km, the number of seals observed per kilometer yields a sighting rate of 0.12 harbor seals/km.

Figure 2. Harbor seals observed during systematic line transect surveys in groups of 1 or 2 individuals.

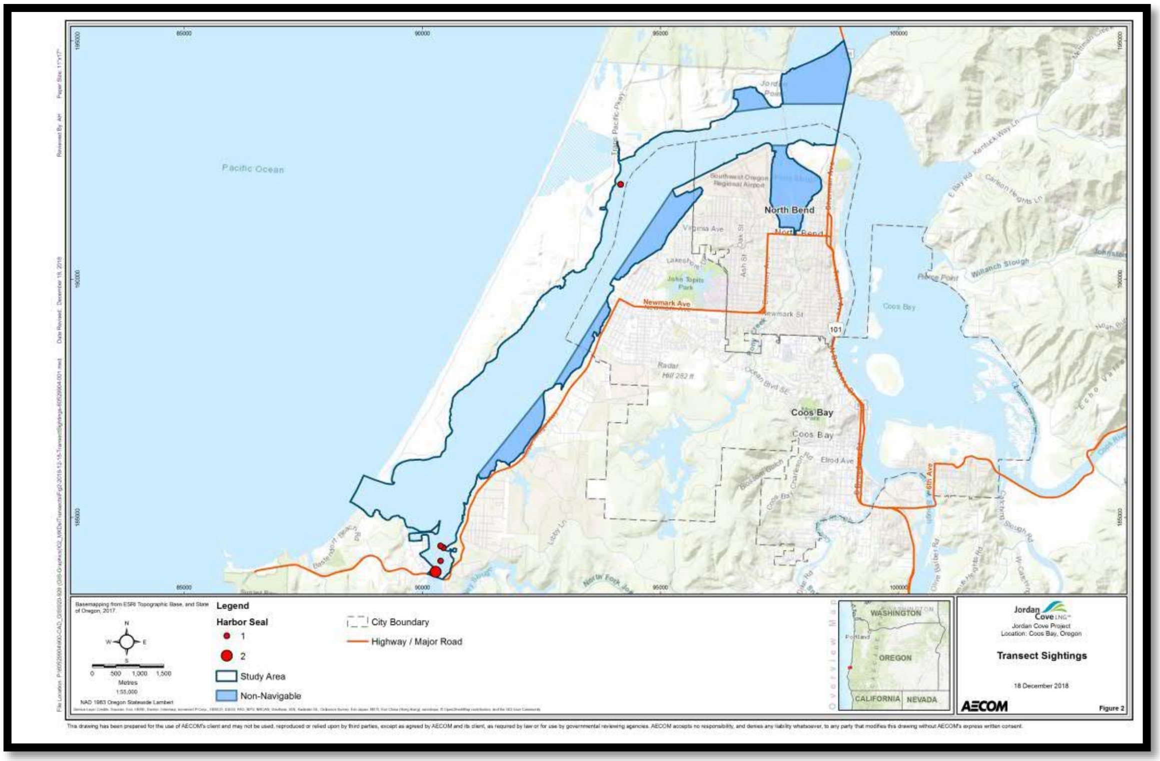


Table 2. Marine mammal species observed during line transect surveys.

Date	Species	Number	Time	Behaviour
26-Nov-18	Harbor Seal	1	1102	Floating
28-Nov-18	Harbor Seal	1	0836	Swimming
28-Nov-18	Harbor Seal	1	0832	Swimming
28-Nov-18	Harbor Seal	1	1300	Floating
28-Nov-18	Harbor Seal	2	1303	Swimming

Photograph 1. Single harbor seal observed during line transect surveys in shallow water near Clam Island haul out site.

Opportunistic Observations

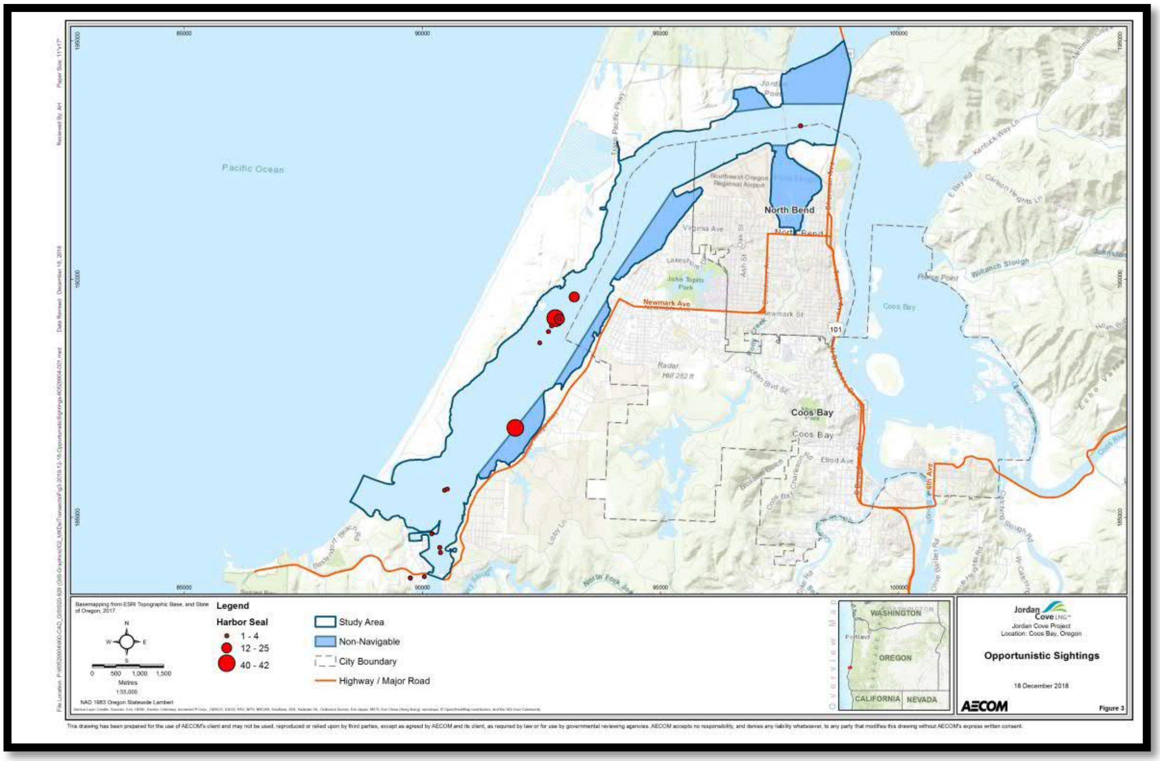
In addition, to the systematic line transect data, opportunistic sightings data were also recorded. There were 17 sightings of varying group sizes of harbor seals ranging from single animals to large groups exceeding 20 individuals (Figure 3, Table 3). No other marine mammal species were sighted, and no identifiable harbor seal pups were observed (Table 3). The large groups of harbor seals were observed both in the water and hauled out (Table 3). Hauled out harbor seals were observed at Clam Island and on the tidal island in the Pigeon Point area (photographs 2 and 3).

For three sightings, the group sizes had to be estimated as a range (Table 3). For these estimate, the minimum was based on the number of animals that could be accurately counted (e.g. 28, Table 3), while the maximum was based on the estimated highest number present (e.g. 56, Table 3). As result of the low relief of the two haul out sites, it was not possible to accurately count all the hauled out seals from the vessel, and best estimates had to be made to gauge the upper limit of the groups. Based on these opportunistic data (Table 3), the minimum (n=117) total and maximum (n=165) total number of seals observed, and the non-line transect at-sea effort expended (180.2 km), the harbor seals sighting rate ranged from 0.65 – 0.92 harbor seals/km.

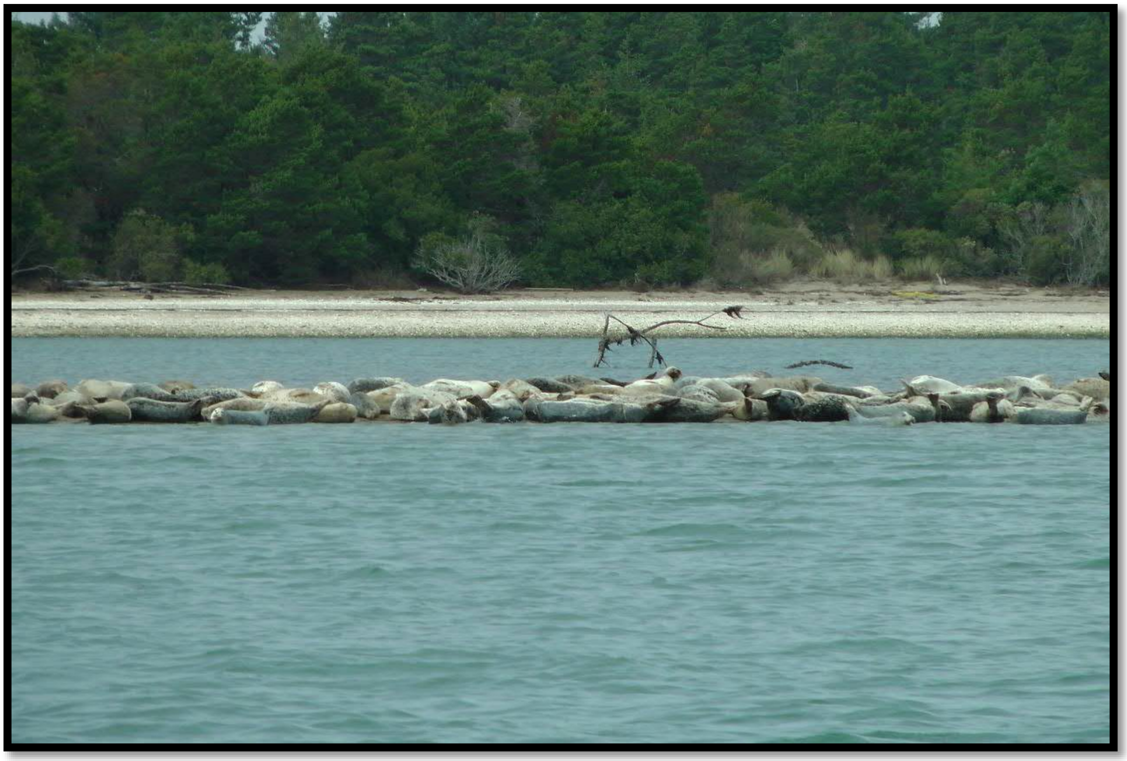
Table 3. Opportunistic Data Summary.

Date	Species	Number	Time	Behaviour
26-Nov-18	Harbor seal	1	1000	Swimming
26-Nov-18	Harbor seal	1	1130	Swimming
26-Nov-18	Harbor seal	1	1630	Swimming
27-Nov-18	Harbor seal	1	850	Swimming
27-Nov-18	Harbor seal	3	854	Swimming
27-Nov-18	Harbor seal	20-30	855	Floating
27-Nov-18	Harbor seal	3	1040	Floating
27-Nov-18	Harbor seal	12	1110	Floating
27-Nov-18	Harbor seal	1	1202	Swimming
27-Nov-18	Harbor seal	1	1452	Floating
28-Nov-18	Harbor seal	1	831	Swimming
28-Nov-18	Harbor seal	1	842	Swimming
28-Nov-18	Harbor seal	40-50	858	Hauled Out
28-Nov-18	Harbor seal	28-56	1130	Hauled Out
28-Nov-18	Harbor seal	1	1305	Swimming
28-Nov-18	Harbor seal	1	1315	Swimming
28-Nov-18	Harbor seal	1	1317	Swimming

Figure 3. Opportunistic sightings data of harbor seals in varying group sizes.



Photograph 2. Harbor seals hauled out on the north end of Clam Island as tide is rising.



Photograph 3. Harbor seals hauled out on tidal island near Pigeon Point as tide is rising.

Aerial Drone Photographic Data

In addition to the systematic and opportunistic marine survey visual data, additional visual data were collected using aerial drone photography on 19, 20, 26 November 2018 and 6 December 2018 at or near the daytime low tides (Table 5). Data collection was limited by heavy fog on 19 November 2018 and the effort had to be discontinued due to flight regulations. On 20 November 2018, both the Pigeon Point area and Clam Island were photographed, but harbor seals were only hauled out at Clam Island. On this day, it was apparent that a number of people were harvesting shellfish (clams) in the Pigeon Point area, this may have influenced the seals haul out behavior.

The aerial drone photographs provided information on the number of seals hauled out throughout the study area, and from this AECOM calculated an estimate of the relative density of harbor seals in the study area. This estimate was informed by that fact that only two haul out sites were detected during the line transect surveys, and both haul outs were aerially documented.

The maximum number of hauled out seals was 167, documented at Clam Island on 20 November 2018 (Table 5). The total number of seals hauled out on 26 November and 6 December 2018 was 128, but on 26 November the animals were dispersed between the two haul out sites (Table 5). The tidal island near Pigeon Point was only documented to have seals hauled out on 26 November 2018 with a total number of 41 harbor seals (Table 5). Based on these counts, an estimate of relative density can be determined for the study area and ranges from 8.5 - 11.1 harbor seals/km^2.

Table 5. Aerial photography results summary

Date	Conditions	Number of Photographs	Number of Harbor Seals	Location of Harbor Seals
19-Nov-2018	Clear then fog	1	0	--
20-Nov-2018	Very smoky, wind no precipitation	32	167 0	Clam Island Near Pigeon Point
26-Nov-2018	Overcast Light wind	33	87 41	Clam Island Near Pigeon Point
6-Dec-2018	Sunny	19	128 0	Clam Island Near Pigeon Point

Photograph 4. Aerial drone photograph of hauled out harbor seals at Clam Island near low tide (6 December 2018).

Photograph 5. Aerial drone photograph of harbor seals hauled out on the tidal island near Pigeon Point near low tide (26 November 2018).

Underwater Acoustics

Eighteen acoustic recordings were made on 26, 27, 28 November 2018 during the line transect field survey. Interval recordings ranging from 0.41 – 10.07 minutes were made, with 14 of the acoustic samples greater than 5 minutes in length. Acoustic samples were recorded for the maximum time up to 10 minutes, but were limited by navigational safety due to vessel drift and shallow bathymetry. In total, 2.28 hours (136.8 minutes) of ambient underwater acoustic recordings were collected.

While no detailed acoustic analyses were conducted, the relative ambient noise level was calculated for each acoustic sample collected from throughout the study area. The root mean square (rms) values show the variation in the underwater acoustic environment that was present during the sampling period (Table 4). Acoustic sample locations were recorded, but were generally described based on the relative location or presence of identifiable landmark (i.e. Highway 101 Bridge) (Table 4).

The ambient noise levels ranged from 84.7 – 134.9 rms dB re 1µPa (Table 4), with the highest levels recorded on 28 November 2018 in the Lower Estuary. The lowest ambient noise levels were also recorded in the lower estuary with a value of 84.7 rms dB re 1µPa on 26 November 2018 (Table 4).

The acoustic recordings were also briefly reviewed for potential marine mammal vocalizations, but nothing was identified.

Table 4. Ambient root mean square (RMS) underwater noise levels throughout Coos Bay estuary study area.

Date	General Area Description	RMS (dB re 1µPa)
26-Nov-18	Near Highway 101 Bridge	120.2
26-Nov-18	Near Highway 101 Bridge	120.1
26-Nov-18	Near Roseburg Forest Products Chip Terminal	119.7
26-Nov-18	Central Coos Bay Estuary	120.1
26-Nov-18	Lower Coos Bay Estuary	84.7
26-Nov-18	Lower Coos Bay Estuary	124.1
26-Nov-18	Near Roseburg Forest Products Chip Terminal	120.7
26-Nov-18	Near Highway 101 Bridge	124.3
27-Nov-18	Near Jordan Cove (by Train Bridge)	120.1
27-Nov-18	Central Coos Bay Estuary	120.6
27-Nov-18	Near Jordan Cove (mid Channel)	121.8
28-Nov-18	Near Clam Island	120.5
28-Nov-18	Near Highway 101 Bridge	120.2
28-Nov-18	Between Jordan Cove and Airport	122.3
28-Nov-18	Near Roseburg Forest Products Chip Terminal	119.5
28-Nov-18	Lower Coos Bay Estuary	118.0
28-Nov-18	Lower Coos Bay Estuary	123.1
28-Nov-18	Lower Coos Bay Estuary	134.9

Summary and Conclusions

AECOM undertook a comprehensive marine mammal survey throughout the western half of the Coos Bay estuary from the Highway 101 Bridge to the seaward entrance to Coos Bay (Figure 1) over seven days in November and December 2018. These data were collected to provide a seasonal perspective to the marine mammal data collected in May 2017, and to add to the existing knowledge base for this region. The 2018 survey included visual line transect, opportunistic, underwater acoustic and aerial drone photographic data collection. The 2018 field work was conducted by experienced MMOs in daylight hours with good visibility. The same field personnel were used in both the 2017 and 2018 field efforts.

All four study objectives were successfully achieved. Only a single marine mammal species was observed during the November 2018 field survey. Based on this, there was a decrease in the marine mammal diversity in November from what was observed during the spring 2017 survey. While the survey efforts for both time periods were limited, harbor seals were present in the Coos Bay estuary study area during both the reproductive and non-reproductive seasons. From these observations, the existing literature and the local knowledge collected in May 2017, it is likely that harbor seals are present year-round in the Coos Bay estuary study area. This was also observed by Graybill (1981) and indicates long-term usage of the area by harbor seals.

In terms of the seasonal variation in usage, the systematic line transect harbor seal sighting rate was substantially lower in November 2018 (0.12 harbor seal/km), than in May 2017 (2.87 harbor seal/km). The November/December seasonal estimate of density was determined for the study area using the aerial drone photographs and ranged from 8.5 – 11.1 harbor seals/km^2.

However, it is unknown if the seals photographed at the haul out sites remained within the 15.02 km^2 defined study area or if these animals dispersed into the region of the estuary east of the Highway 101 Bridge or west into the open Pacific Ocean. It is likely that at least some animals would disperse into the Pacific Ocean for foraging and other life functions, including potential interactions with the harbor seals that haul out at Simpsons Reef off Cape Arago. This is the largest harbor seal haul out near Coos Bay (Graybill 1981). It is also unknown whether the harbor seals in this area maintain site fidelity or if their usage of different haul out sites is more fluid. Nevertheless, the harbor seals have to move throughout the study area in order to reach the haul out sites, and at and near low tides, harbor seals are concentrated near the Clam Island and Pigeon Point haul out sites. In addition, the seals were observed to remain near these sites even as the incoming tide reduced the available area for them to haul out on. Both the on- and off-effort sightings data indicate that the harbor seals generally do not remain clustered at these locations once the haul outs are no longer available due to the increasing tidal height.

It is clear that harbor seals make use of the known haul outs at Clam Island and near Pigeon Point when tidally accessible. As the incoming tide reduced the available area for the seals to haul out, the seals remained on and near the haul out (see photographs 3 and 5). As the tide reduced the available area for hauling out, the seals continued to remain near the haul out and were observed in very shallow water, and may have been resting on the submerged haul out until the increasing depth prohibited this behavior.

The haul out at Clam Island appears to be the preferred haul out as the harbor seals were more regularly sighted there, than at the tidal island near Pigeon Point. This observation is consistent with the May 2017 observations and the previous work of Graybill (1981). This habitat preference may be due to the heavy anthropogenic use of the Pigeon Point area at low tide for shellfish harvesting. Harbor seal disturbance by anthropogenic activity on shore in the Coos Bay area was also noted by Graybill (1981). Harbor seal haul out behavior also varies from day to day, which may have been related to the overall weather conditions. This differential use of the two haul outs should be further studied on a monthly basis as this variation may be related to factors not yet identified. The use of the aerial drone photographs would provide a better understanding of the seals response to human activity near each haul out site. This would be beneficial to gauge the potential response to other types of human disturbance in this region.

In terms of the underwater acoustic environment, the ambient rms underwater acoustic levels were generally lower than those recorded during the May 2017 study, and ranged from 84.7 – 134.9 dB re 1µPa rms. It is interesting to note that the highest levels recorded on 28 November 2018 in the Lower Estuary were after a storm event on 27 November 2018 (Photograph 6). The underwater environment in the Lower Estuary may have been influenced by post-storm wave activity in the open waters of the Pacific Ocean. The lowest ambient noise levels were also recorded in the lower estuary with a value of 84.7 dB re 1µPa rms on 26 November 2018 when sea conditions were calmer. Throughout the Coos Bay study area, underwater recordings indicated underwater acoustic rms levels were near or greater than 120 dB re 1µPa rms, and the underwater sound levels near the Jordan Cove Project site were consistent with those recorded in May 2017. The relationship between the underwater ambient levels and the storm activity in the open Pacific Ocean should be further studied.

In summary, the multifaceted approach to data collection utilized during both survey periods (May 2017 and November/December 2018) resulted in a greater understanding of the use of the Coos Bay estuary by marine mammals than a single approach would have. In addition, the local knowledge collected during the May 2017 survey, further added to the understanding of this region's importance to marine mammals. While gaps remain in the year-round use of the region, and as identified in May 2017, there may be ecologically important time periods that remain unstudied (e.g. harbor seal pupping season, salmon migrations, and herring spawning) relative to marine mammals. Collectively, the data collected by Jordan Cove in the two studies in 2017/2018 provide a more solid foundation for the development of the marine mammal management plan for the construction and operation of the proposed Jordan Cove LNG terminal. These results also contribute to the existing data that are available on marine mammals in the Coos Bay estuary.

Photograph 6. Sea conditions at Coos Bay Jetties on 27 November 2018

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———. 2016 (December 6). Oregon Department of Fish and Wildlife, written communication to AECOM, Camarillo, CA.

Appendix B: Memo from Briony Croft, SLR Consulting, regarding the Marine Mammal Noise Impact Assessment, September 15, 2017

Memorandum

To: Drew Jackson

From: Briony Croft

Date: 15 September 2017

Subject: Jordan Cove LNG - Underwater Noise Impact Assessment

This technical memorandum provides a response to Items 8 and 11 from the FERC Environmental Information Request to the Jordan Cove and Pacific Connector Project (Docket No. PF17-4-000). These items request additional information to supplement the RR9 assessment of underwater noise impacts as follows:

8. *Include an evaluation and quantification of noise impacts from sound pressure waves generated within the water due to pile driving and dredging operations, as well as noise due to the operation of the tugs and LNG vessels. Quantify sound pressure levels in the aquatic environment (in dB re: 1μPa) to a distance of 1 mile and discuss impacts to all threatened and endangered aquatic species, marine mammals, and commercial and recreational fish species.*

11. *Estimate potential in-air and underwater noise impacts associated with the construction activities and equipment needed to widen and/or modify the Coos Bay Channel as part of the proposed Pilots Project.*

In addition to this memorandum, supporting documents are attached as follows:

Appendix A – NMFS spreadsheet calculations of potential for permanent threshold shift due to dredging and vessel operations.

1.0 INTRODUCTION

1.1 Project Description

The marine facilities associated with the Jordan Cove Energy Project (JCEP) LNG Terminal will be on the bay side of the North Spit of Coos Bay, Oregon. Construction of the marine facilities will include several activities with the potential to generate underwater noise:

- Dredging of the marine slip, access channel and materials offloading facility (MOF);
- Dredging in areas along the Coos Bay navigation channel as part of the proposed Pilots project;
- Placement of a sheet pile bulkhead; and
- Construction of platforms, fenders and mooring structures.

The construction activities with the most potential for underwater noise generation are dredging and pile driving. Dredging would occur in a staged approach, with as much material as possible removed through excavation in isolation from Coos Bay behind a temporary berm. In-water work including dredging and removal the temporary berm would be undertaken with a cutter suction dredge and a clamshell dredge. The equipment to dredge the Coos Bay navigation channel is yet to be confirmed, but on the basis of comparable projects use of a cutter suction dredge is likely and represents a reasonable worst case for indicative noise impact assessment.

Approximately 3600 pipe piles and over 11,800 sheet piles will be will be required for the project in total, including marine and upland piles. The average length of steel pipe piles will be around 93 feet in length. The largest steel pipe piles to be installed in water are the MOF bollards at 36-inches in diameter. These piles will be installed by hydraulic pile driving (impact hammer). The sheet pile bulkhead forming the MOF and berth walls would be installed by vibratory pile driving.

During operation of the LNG facility, the primary underwater noise sources would be vessels, including LNG ships and tugs. The JCEP LNG Terminal will add approximately 110-120 additional LNG carriers on an annual basis to the existing approximately 50 deep draft vessels per year operating in the area.

1.2 Aquatic Species Considered

Fisheries resources are described in JCEP LNG Terminal Project Resource Report 3 (RR3) Section 3.1. Fish habitat near the JCEP LNG Terminal supports a mix of marine and estuarine species, and both recreational and commercial fishing. Federally listed fish species spending a portion of their life cycle within the estuarine environment of Coos Bay are coho salmon; green sturgeon and eulachon.

RR3 Section 3.1.3 lists non-endangered marine mammals potentially occurring in the region, and Table 3.4-1 lists threatened and endangered species. Non-endangered marine mammal species potentially occurring in the Coos Bay estuary include the California sea lion, Steller sea lion, harbor porpoise, harbor seal, and northern elephant seal. Listed marine mammals occurring in the marine analysis area (which includes the JCEP project area and the LNG carrier transit route) are the blue whale; fin whale; gray whale; humpback whale; sei whale; sperm whale; killer whale and North Pacific right whale. Of these listed marine mammal species, humpbacks, gray whales and killer whales may occasionally enter Coos Bay within the JCEP project area.

Listed sea turtle species in the marine analysis area are loggerhead; leatherback; green; and olive ridley. These species are not expected to occur within the JCEP project area.

This assessment considers the potential for operational noise from vessel traffic in the marine analysis area to affect threatened and endangered aquatic species (fish, marine mammals and sea turtles). Noise from Facility construction activities including piling and dredging is assessed for potential to impact on fish and marine mammals.

1.3 Underwater Noise Sources and Scenarios

The project description has been used to develop a list of equipment with the potential to generate underwater noise. Overall broadband source noise levels at a 1m (3.3 feet) reference distance have been determined for each potential noise source from literature as shown in Table 1. Two different parameters are used to describe the source levels. The peak noise level is the short term maximum sound pressure level (SPL). It is used to describe the maximum noise level from an impulsive or short term event such as a hydraulic hammer striking a pile. The Root Mean Square (RMS) noise level is a type of average noise level over a time period of interest. RMS can be used to describe noise from a continuous source or the average noise during an impulsive event over a defined time period. All peak and RMS underwater sound levels in this report are described in decibels (dB) referenced to 1 micro Pascal (1 µPa).

A third parameter is used in this assessment as a descriptor of potential impacts, the Cumulative Sound Exposure Level (SEL_{cum}). This parameter describes the cumulative noise exposure from repeated or extended duration events such as piling hammer strikes or long term exposure to continuous noise. SEL_{cum} has units of dB re 1 $\mu Pa^2 s$.

Source levels for a range of sizes of support vessels have been estimated by scaling from frequency dependent reference vessel noise measurements, using the formulation described in Ross (1976) to adjust source levels on the basis of ship length, power and speed, as applied by Wales and Heitmeyer (2002).

Noise from large vessels (adjusted to a 1m reference distance) can range up to 188 dB re 1µPa (McKenna et al. 2012). In practice, noise from vessels will vary depending on vessel size and power, propulsion system loading and vessel speed. A typical transit speed for vessels within the Coos Bay navigation channel of 7 knots has been assumed for this assessment. At these speeds, transiting vessel noise emissions are reduced relative to noise at higher speeds. JASCO (2006) state that broadband noise from LNG vessels at half speed is expected to be around 175 dB re 1µPa at the 1m reference distance.

Noise from tugs under load is less speed dependent. Tugs under load can be noisier than larger vessels.

Noise from cutter suction dredges varies with the capacity of the dredger and the type of material being dredged. Reine et al (2014) measured source levels for a cutter suction dredger removing rock in New York Harbor of up to 175 dB re 1µPa at 1m. A smaller dredger with overall length approximately 100 ft., a total power of 1000 hp operating the main pumps, and with dredged material moving through a 16-in. pipeline undertaking maintenance dredging in a deep water shipping channel has been recorded with source levels up to 157 dB re 1µPa at 1m (Reine and Dickerson, 2014). Use of a similar dredge is anticipated for JCEP dredging. For this assessment, a dredging source noise level of 157 dB re 1µPa at 1m is assumed. The potential noise impacts of a larger dredger are also considered in this assessment as a worst case to assess the potential impact of dredging work in the Coos Bay navigation channel.

Underwater noise from piling is described in Caltrans (2015). This reference includes specific source levels for driving steel sheet piles and 36 inch diameter steel pipe piles.

Table 1 Broadband Source Noise Levels

Noise Source	Description	Peak dB re. 1µPa @ 1 m	RMS dB re. 1µPa @ 1 m	Reference
LNG vessel	Transiting 7 knots / half speed	n/a	175	McKenna et al 2012; JASCO, 2006.
Tugs and smaller support vessels	120' and up to 5400 HP	n/a	170	Warner et al, 2014
	150' and up to 6600 HP	n/a	175	Li et al, 2011
	220' and up to 10560 HP (LNG escort tug)	n/a	185	Jasco, 2006
Cutter Suction Dredging	Marine slip, access channel and MOF	n/a	157	Reine & Dickerson, 2014
	Coos Bay navigation channel	n/a	175	Reine et al, 2014
Sheet pile driving	Vibratory pile driving	195	180	Caltrans, 2015
	Impact hammer driving	225	210	Caltrans, 2015
36 inch steel pipe pile driving	Vibratory pile driving	200	190	Caltrans, 2015
	Impact hammer driving	230	213	Caltrans, 2015

Note 1: Source levels may vary over time with variations in propulsion system loading and vessel speed.

2.0 FISH AND SEA TURTLE NOISE IMPACT THRESHOLDS

Threshold levels for underwater noise impacts on fish and sea turtles have been the subject of research over many years. The majority of research has focused on the potential for physiological effects (injury or mortality) rather than on quantifying noise levels with behavioral effects. A review of the literature and guidance on appropriate thresholds for assessment of underwater noise impacts are provided in the 2014 Acoustical Society of America (ASA) Technical Report *Sound Exposure Guidelines for Fishes and Sea Turtles* (ASA, 2014).

The ASA Technical Report includes thresholds for mortality (or potentially mortal injury) as well as degrees of impairment such as temporary or permanent threshold shifts (TTS or PTS, indicators of hearing damage). Thresholds are defined for peak noise and cumulative impacts (due to continuous or repeated noise events) and for different noise sources (eg pile driving, and continuous noise from vessels or dredging). For continuous noise from vessels or dredging, there is a low risk of mortality or injury for any fish types or sea turtles. Piling noise results in higher noise levels and hence an increased potential for injury. The ASA guideline injury thresholds for piling noise for fish and sea turtles are summarized in Table 2.

Table 2 Underwater acoustic thresholds for fish and sea turtles during piling

Type of Animal	Mortality	Recoverable Injury	TTS
Fish: no swim bladder	> 219 dB SEL_{cum}; or > 213 dB Peak	>216 dB SEL_{cum}; or > 213 dB Peak	>> 186 dB SEL_{cum}
Fish: swim bladder not involved in hearing	210 dB SEL_{cum}; or > 207 dB Peak	203 dB SEL_{cum}; or > 207 dB Peak	> 186 dB SEL_{cum}
Fish: swim bladder involved in hearing	207 dB SEL_{cum}; or > 207 dB Peak	203 dB SEL_{cum}; or > 207 dB Peak	186 dB SEL_{cum}
Sea turtles	210 dB SEL_{cum}; or > 207 dB Peak	High risk near the source only (within tens of meters)	

Notes: Peak sound pressure has a reference value of 1 µPa and is "flat" or unweighted.
Cumulative sound exposure level (SEL_{cum}) has a reference value of 1µPa^{2}s.

Since soft start methods will be used as a mitigation measure for piling, and animals in the vicinity of noise sources will be free to move away, this assessment of impacts to fish focusses on the potential for peak noise levels during piling to cause mortality or injury. These effects are not anticipated at noise levels below about 207 dB re 1µPa, or at higher levels for species without swim bladders.

3.0 MARINE MAMMAL NOISE IMPACT THRESHOLDS

Guidance on acoustic thresholds for injury (hearing damage) in the form of permanent threshold shift (PTS) and disturbance are provided by the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS).

3.1 Acoustic Thresholds for Disturbance

The NMFS interim underwater thresholds for behavioral effects are shown in Table 3 (NMFS, 2012). Of the sources considered, the majority are "continuous" for the purpose of this assessment, with only the noise from impact pile driving treated as impulsive.

Table 3 Interim underwater acoustic thresholds for behavioral disruption

Criterion Definition	Threshold
Behavioral disruption for impulsive noise (e.g., impact pile driving)	160 dB_{rms}
Behavioral disruption for non-impulsive noise (e.g., vibratory pile driving, vessels)	120 dB_{rms}

Notes: dB referenced to 1 micro Pascal (re: 1µPa).
All thresholds are based off root mean square (rms) levels and are broadband (unweighted).
The 120 dB threshold may be slightly adjusted if background noise levels are at or above this level.

3.2 Acoustic Thresholds for Injury (Permanent Hearing Damage, PTS)

Acoustic thresholds related to PTS are provided by Technical Memorandum NMFS-OPR-55 *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts* (NMFS, 2016).

A dual metric approach is used for impulsive sounds, considering both cumulative sound exposure level and peak sound level. Different thresholds and auditory weighting functions are provided for different marine mammal hearing groups, which are defined in the Technical Guidance (NMFS, 2016). The generalized hearing range of each hearing group is reproduced in Table 4. The PTS thresholds are shown in Table 5. The non-endangered marine mammal species potentially occurring in the Coos Bay estuary include otariid pinnipeds (California sea lion, Steller sea lion), phocid pinnipeds (harbor seal, northern elephant seal) and the high frequency cetacean harbor porpoise. The listed marine mammal species which may occasionally enter Coos Bay within the JCEP project area are humpbacks and gray whales (low frequency cetaceans) and killer whales (mid frequency cetaceans).

Table 4 Cetacean hearing groups (from NMFS, 2016)

Hearing Group	Generalized Hearing Range
Low-frequency cetaceans	7 Hz to 35 kHz
Mid-frequency cetaceans	150 Hz to 160 kHz
High-frequency cetaceans	275 Hz to 160 kHz
Phocid pinnipeds	50 Hz to 86 kHz
Otariid pinnipeds	60 Hz to 39 kHz

Table 5 Underwater acoustic thresholds for PTS onset

Hearing Group	PTS Onset Acoustic Thresholds (Received Level)		
	Impulsive (Peak, L_{pk}, flat)	Impulsive (SEL_{cum}, weighted, 24h)	Non-impulsive (SEL_{cum}, weighted, 24h)
Low-frequency cetaceans	219 dB	183 dB	199 dB
Mid-frequency cetaceans	230 dB	185 dB	198 dB
High-frequency cetaceans	202 dB	155 dB	173 dB
Phocid pinnipeds	218 dB	185 dB	201 dB
Otariid pinnipeds	232 dB	203 dB	219 dB

Notes: Peak sound pressure (L_{pk}) has a reference value of 1 μPa and is "flat" or unweighted.
Cumulative sound exposure level (SEL_{cum}) has a reference value of 1μPa^{2}s.
SEL_{cum} received levels should be appropriately weighted for the hearing group for assessment.

4.0 NOISE LEVEL VS DISTANCE

For the purpose of this impact assessment, the objective is to quantify the noise level due to various sources at a range of distances out to 1 mile. These noise levels will then be discussed in relation to their potential to cause injury or disturbance to the species of interest, with reference to the identified thresholds.

4.1 Noise Level vs Distance

The magnitude of the noise level at a particular location depends strongly on the distance from the noise source. Underwater noise propagation models predict the sound transmission loss between the noise source and the receiver. When the source level (SL) of the noise source is known, the predicted transmission loss (TL) is then used to predict the received level (RL) at the receiver location as:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{TL}$$

The transmission loss between two distances D1 and D2 may be described by a logarithmic relationship with an attenuation factor F:

$$\mathrm{TL} = \mathrm{F} \cdot \log(\mathrm{D}_1/\mathrm{D}_2)$$

If all losses due to factors other than geometric spreading are neglected, then the transmission loss would be wholly due to spherical spreading (in deep water) or cylindrical spreading (in shallow water, bounded above and below). Spherical spreading means underwater noise would attenuate by 6 dB with each doubling of distance, or F = 20. Cylindrical spreading means an attenuation of 3 dB with each doubling of distance, or F = 10.

In shallow water, noise propagation is highly dependent on the properties of the bottom and the surface as well as the properties of the fluid. Parameters such as depth and the bottom properties can vary with distance from the source. Sound energy at low frequencies may be transferred directly into the sea floor, rather than propagating through the water. Overall, the transmission loss in shallow water is a combination of cylindrical spreading effects, bottom interaction effects (absorption) at lower frequencies and scattering losses at high frequencies.

In practical cases the attenuation factor F can range from 5 up to 30. A "practical spreading loss model" based on an attenuation factor of 15 for sound transmission is commonly assumed for projects near shore (NMFS, 2012) and has been adopted for this study.

The noise attenuation vs distance is shown in Figure 1. The noise level from the various sources at a range of distances out to 1 mile is summarized in Table 6. Note that in situations with more than one noise source or several vessels operating in an area, the loudest or closest source may be assumed to dominate at any particular receiver location.

Figure 1 Noise Attenuation vs Distance – Practical Spreading Loss Model

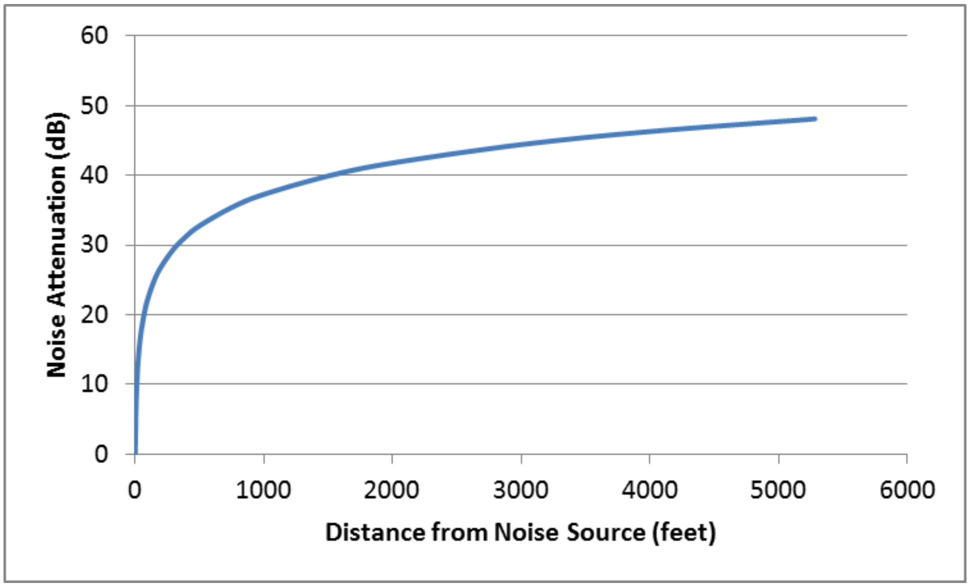

Table 6 Peak and RMS Noise Level vs Distance by Source

Parameter	Noise Source	3.3 ft	50 ft	100 ft	500 ft	1000 ft	1 mile
RMS dB re. 1µPa	LNG Vessel	175	157	153	142	138	127
	120' Support Vessel	170	152	148	137	133	122
	150' Support Vessel	175	157	153	142	138	127
	220' LNG escort tug	185	167	163	152	148	137
	CSD – marine slip, access channel, MOF	157	139	135	124	120	109
	CSD – worst case Coos Bay nav. channel	175	157	153	142	138	127
	Vibratory sheet pile driving	180	162	158	147	143	132
	Impact sheet pile driving	210	192	188	177	173	162
	Vibratory steel pipe pile driving	190	172	168	157	153	142
	Impact hammer steel pipe pile driving	213	195	191	180	176	165
Peak dB re. 1µPa	Vibratory sheet pile driving	195	177	173	162	158	147
	Impact sheet pile driving	225	207	203	192	188	177
	Vibratory steel pipe pile driving	200	182	178	167	163	152
	Impact hammer steel pipe pile driving	230	212	208	197	193	182

5.0 DISCUSSION OF POTENTIAL PROJECT UNDERWATER NOISE IMPACTS TO FISH AND SEA TURTLES

As identified in Section 2.0, mortality or injury to fish or sea turtles of any species is not anticipated at peak noise levels below about 207 dB re 1µPa, or at higher levels for species without swim bladders.

Of the various activities with the potential to generate underwater noise, only piling using an impact hammer has source levels that are high enough to potentially cause injury or mortality to fish. Impact driving of steel pipe piles is noisier than impact driving of sheet piles. For sheet piles, the potential for injury to fish is limited to within 50 feet of the noise source, in a worst case situation. For steel pipe piles, this distances increases to about 100 feet, again under worst case assumptions. Soft start methods will be used as a mitigation measure for piling, with the initial strikes applied at lower power with reduced noise levels. The areas with potential piling noise physical impacts to fish would be within the excavated and dredged area required to construct the marine facility.

Fish behavioral responses to noise from piling activity may occur over greater distances. ASA (2014) indicates a high risk of behavioral effects to fish during piling in the near to intermediate field, ie within distances of tens to hundreds of meters. The risk of behavioral effects in the far field (of the order of thousands of meters or miles) reduces to moderate. In light of the Facility location in Coos Bay, the potential for adverse behavioral impacts to fish outside of the immediate project construction vicinity (within about 1 mile) is considered to be low.

With reference to ASA (2014), the risk of adverse fish behavioral responses to noise from dredging and vessel activity is also expected to be low except in the immediate vicinity of the noise source. The noise from project dredging and vessel movements will be similar to noise from existing dredging activity and vessel movements in the Coos Bay navigation channel. Similarly the risk of adverse sea turtle behavioral responses to noise from vessel activity is low, with the noise from project activity similar to noise from existing shipping activity.

6.0 DISCUSSION OF POTENTIAL PROJECT UNDERWATER NOISE IMPACTS TO MARINE MAMMALS

6.1 Marine Mammal Impulsive Peak Noise PTS Potential

As identified in Section 3.2, permanent hearing damage to marine mammals of any species is not anticipated at impulsive peak noise levels below 202 dB re 1µPa, with the lowest threshold applicable to high frequency cetaceans which include harbor porpoises. For low and mid frequency cetaceans and pinnipeds (ie for all other species potentially affected by the project), the impulsive peak noise injury threshold is higher, above 218 dB re 1µPa.

Marine mammals inside Coos Bay in the vicinity of the Facility may be affected by noise from piling during construction. Of the various piling scenarios, only the use of an impact hammer has impulsive peak source levels that are high enough to cause PTS in any species. The greatest distance at which PTS due to impulsive peak noise may possibly occur is around 250 feet for the harbor porpoise. Soft start methods will be used as a mitigation measure for piling, with the initial impacts applied at lower power with reduced noise levels and hence reduced potential for impacts. On this basis, injury in the form of PTS to any marine mammal species is not anticipated as a result of impulsive peak noise emissions during project piling.

6.2 Marine Mammal Cumulative Noise Exposure PTS Potential

The NMFS 2016 Technical Guidance provides a calculation method for determining the potential for cumulative noise to have adverse effects to marine mammal hearing. This method includes multiple conservative assumptions and is therefore expected to result in higher estimates of hearing impairment that would be the case in a practical situation. An assessment using the NMFS spreadsheet calculator has been undertaken for each of the vessel and dredging noise sources and scenarios. Calculation sheets detailing the various assumptions and the distance to the cumulative noise PTS threshold for each noise source are attached as Appendix A. More detailed site specific investigations of the potential for cumulative piling noise impacts have been investigated by JASCO (Deveau and MacGillvray 2017, O'Neill and MacGillivray 2017) and are attached as Appendices B and C. For most species, activities and scenarios, there is very low risk of cumulative PTS in practice since individual animals would need to remain in close proximity to the noise source for an extended period of time, without moving away. The results of these various cumulative noise impact calculations are summarized as follows:

- During dredging to construct the marine facility, individual harbor porpoises would need to remain within about 500 feet of the dredge for 24 hours for there to be a potential for PTS. Other marine mammals would need to remain effectively immediately adjacent to the dredge for the same duration.
- During dredging of the navigation channel, individual harbor porpoises would need to remain within about 1.6 miles of the dredge for 24 hours for there to be a potential for PTS. Killer whales would need to remain within about 180 feet of the dredge again for 24 hours for there to be potential for PTS. Other marine mammals would need to remain effectively immediately adjacent to the dredge for the same duration.
- When tugs are operating semi-stationary under full power near the Facility, individual harbor porpoises would need to remain within about 1 mile of the tug for 1 hour for there to be a potential for PTS. Killer whales would need to remain within about 100 feet of the tug for 1 hour for there to be potential for PTS.
- During 36" steel pipe pile installation using a vibratory driver, individual harbor porpoises would need to remain within about 1.3 miles of the noise source during the driving of approximately 3 individual piles (1000 strikes) for there to be potential for PTS. Harbor seals and killer whales would need to remain within 1.1 miles of the noise source for the same duration for PTS to potentially occur.
- The noise from transiting vessels and tugs does not represent a potential risk of PTS to any of the identified marine mammal species, at any realistically occurring distance.

There is potential for cumulative noise exposure to cause PTS in harbor porpoises (high frequency cetaceans) during in water piling, particularly when a hydraulic impact hammer is used. For PTS to occur, harbor porpoises would need to remain in the vicinity during extended periods of impact piling. The potential for PTS to occur in other marine mammals is less, due to the differing hearing sensitivities of other species. The use of a combination of engineered underwater noise mitigation measures (such as pile cushions, bubble curtains) and management techniques (including soft starts, protected species observers and exclusion zones) is expected to minimize the potential for acoustic injury to marine mammals.

6.3 Marine Mammal Behavioral Disturbance Potential

Away from the JCEP project area, the potential for effects to threatened and endangered marine mammals is limited to behavioral disturbance due to noise from piling, navigation channel dredging, LNG vessels, tugs and potentially other support vessels. Vibratory sheet pile driving has the potential to exceed the NMFS interim behavioral disturbance threshold of 120 dB re 1 µPa at distances of up to 1.2 miles (Deveau and MacGillvray, 2017). Impact pipe pile driving has the potential to exceed the NMFS interim behavioral disturbance threshold of 160 dB re 1 µPa at similar distances (O'Neill and MacGillvray, 2017).

The noise from project vessel movements and dredging will be similar to noise from existing vessel and dredging activity in the Coos Bay navigation channel.

7.0 SUMMARY

This assessment provides quantitative levels for underwater noise generated by the Jordan Cove LNG project and potential impacts to marine mammals, threatened and endangered aquatic species and to commercial and recreational fish species.

Of the various activities with the potential to generate underwater noise, only piling using an impact hammer has source levels that are high enough to cause potential injury or mortality to fish. In the noisiest scenario, potential physical impacts to fish would be restricted to areas within about 100 feet of the noise source, inside the excavated and dredged area required to construct the marine facility. The potential for adverse behavioral impacts to fish outside of the immediate project construction vicinity (at distances greater than about 1 mile) is considered to be low, for all construction scenarios.

The noise from project dredging and vessel movements will be similar to noise from existing dredging activity and vessel movements in the Coos Bay navigation channel, with a low risk of adverse fish behavioral responses to these noise sources.

Harbor porpoises (which are not endangered) are the only high frequency cetacean that may occur in the vicinity of the Facility. If present, this marine mammal species has the greatest potential to be affected by noise from piling or other marine facility construction noise sources. Permanent hearing impairment harbor porpoises is not anticipated as a result of impulsive peak noise emissions during project piling, provided they are not present with 250 feet of piling using an impact hammer. Individual harbor porpoises would need to remain with about 1.3 miles of the facility for the full duration of driving 3 of the largest marine pipe piles to risk permanent hearing impairment due to the cumulative noise effects of piling.

In relation to other marine mammals and the identified threatened and endangered species, there is a lower risk of permanent hearing impairment due to project noise. There is potential for behavioral disturbance due to noise from dredgers, LNG vessels, tugs and other support vessels. The noise disturbance from project vessel movements and dredges will be similar to noise from existing vessel and dredging activity in the Coos Bay navigation channel.

8.0 REFERENCES

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9.0 STATEMENT OF LIMITATIONS

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APPENDIX A
NMFS spreadsheet calculations of potential for permanent threshold shift due to dredging and vessel operations

Jordan Cove LNG - Underwater Noise Impact Assessment

A: STATIONARY SOURCE: Non-Impulsive, Continuous

VERSION: 1.1 (Aug-16)

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	JCEP LNG - Dredging
PROJECT/SOURCE INFORMATION Please include any assumptions	As per information contained in Resource Reports 1,3,9
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	42	Default for high-frequency cetaceans (harbor porpoises) as a worst case

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	157
Activity Duration (hours) within 24-h period	24
Activity Duration (seconds)	86400
10 Log (duration)	49.37
Propagation (xLogR)	15
Distance of source level measurement (meters)⁺	1

⁺Unless otherwise specified, source levels are referenced 1 m from the source.

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW): true seals
Otariid pinnipeds (OW): sea lions and fur seals

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**0.3**	**3.5**	**167.6**	**0.6**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-15.27**	**-0.28**	**0.00**	**-8.68**	**-11.01**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

A: STATIONARY SOURCE: Non-Impulsive, Continuous

VERSION: 1.1 (Aug-16)

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Dredging Coos Bay navigation channel
PROJECT/SOURCE INFORMATION (Please include any assumptions)	As per information contained in Resource Reports 1,3,9
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	42	Default for high-frequency cetaceans (harbor porpoises) as a worst case

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	175
Activity Duration (hours) within 24-h period	24
Activity Duration (seconds)	86400
10 Log (duration)	49.37
Propagation (xLogR)	15
Distance of source level measurement (meters)[+]	1

[+]Unless otherwise specified, source levels are referenced 1 m from the source.

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW):true seals
Otariid pinnipeds (OW):sea lions and fur seals

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**4.7**	**54.8**	**2,655.9**	**9.5**	**0.4**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-15.27**	**-0.28**	**0.00**	**-8.68**	**-11.01**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

A: STATIONARY SOURCE: Non-Impulsive, Continuous

VERSION: 1.1 (Aug-16)

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	JCEP LNG - Stationary tug
PROJECT/SOURCE INFORMATION Please include any assumptions	As per information contained in Resource Reports 1,3,9. Stationary tug assumed working near facility 4 hours active in any one day.
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	42	Default for high-frequency cetaceans (harbor porpoises) as a worst case

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	185
Activity Duration (hours) within 24-h period	1
Activity Duration (seconds)	3600
10 Log (duration)	35.56
Propagation (xLogR)	15
Distance of source level measurement (meters)⁺	1

⁺Unless otherwise specified, source levels are referenced 1 m from the source.

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW):true seals
Otariid pinnipeds (OW):sea lions and fur seals

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**2.6**	**30.6**	**1,481.6**	**5.3**	**0.2**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-15.27**	**-0.28**	**0.00**	**-8.68**	**-11.01**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

C: MOBILE SOURCE: Non-Impulsive, Continuous (SAFE DISTANCE METHODOLOGY‡)

VERSION: 1.1 (Aug-16)

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	JCEP LNG -LNG Vessel in transit 7 knots
PROJECT/SOURCE INFORMATION (Please include any assumptions)	As per information contained in Resource Reports 1,3,9
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	42	Default for high-frequency cetaceans (harbor porpoises) as a worst case

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	175
Source Velocity (meters/second)	3.6
Duty cycle	1
Source Factor	3.16228E+17

‡Methodology assumes propagation of 20 log R; Activity duration (time) independent

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW): true seals
Otariid pinnipeds (OW): sea lions and fur seals

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**0.0**	**0.0**	**1.4**	**0.0**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-15.27**	**-0.28**	**0.00**	**-8.68**	**-11.01**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a\,[1+(f/f_2)^2]^b}\right\}$$

C: MOBILE SOURCE: Non-Impulsive, Continuous (SAFE DISTANCE METHODOLOGY[‡])

VERSION: 1.1 (Aug-16)

KEY

(green)	**Action Proponent Provided Information**
(pink)	**NMFS Provided Information (Acoustic Guidance)**
(blue)	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	JCEP LNG - Escort Tug in transit 7 knots
PROJECT/SOURCE INFORMATION Please include any assumptions	As per information contained in Resource Reports 1,3,9
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	42	Default for high-frequency cetaceans (harbor porpoises) as a worst case

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	185
Source Velocity (meters/second)	3.6
Duty cycle	1
Source Factor	3.16228E+18

‡Methodology assumes propagation of 20 log R; Activity duration (time) independent

Marine Mammal Hearing Group
Low-frequency (LF) cetaceans: baleen whales
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales
High-frequency (HF) cetaceans: true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*
Phocid pinnipeds (PW):true seals
Otariid pinnipeds (OW):sea lions and fur seals

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**0.0**	**0.0**	**13.8**	**0.0**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-15.27**	**-0.28**	**0.00**	**-8.68**	**-11.01**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a\,[1+(f/f_2)^2]^b}\right\}$$

Appendix C: JASCO Technical Memorandum, Jordan Cove Impact Pile Driving Underwater Noise Modeling, Phase 5, June 29, 2018

Jordan Cove Impact Pile Driving Underwater Noise Modeling Phase 5

Marine Mammal and Fish Injury Radii for Reduced Hammer Energy

Submitted to:
Melinda Schulze
AECOM Environment
Project number: 60529904
PO number: 86019

Authors:
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29 June 2018

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

1. Introduction

This technical memorandum presents the Phase 5 results from a modeling study of underwater noise from impact pile driving during construction of the proposed Jordon Cove LNG Terminal at Coos Bay. This study was undertaken by JASCO Applied Sciences (JASCO) on behalf of AECOM, to support an application for a Marine Mammal Protection Act Incidental Harassment Authorization. Previous phases of this project have investigated radii to marine mammal and fish threshold criteria from a pipe pile with the same diameter (36 inch (0.9 m)) but a shorter length (60 ft (18.3 m)), as well as different number of strikes in a 24-hr period and at 4 set-back locations behind the MOF (O'Neill and MacGillivray 2017, Wladichuk et al. 2017, Wladichuk and MacGillivray 2018). After receiving additional construction details, the current phase examines the threshold radii from driving a 104.8 ft (31.9 m) pile at the MOF and at 98.4 ft (30 m) set-back distance behind the MOF using a reduced impact hammer energy of 65%.

The purpose of the present study is to compute distances to marine mammal and fish injury thresholds based on National Marine Fisheries Service (NMFS) 2016, Fisheries Hydroacoustic Working Group (FHWG) 2008, and Popper et al. 2014 criteria for pile driving. Transmission of noise from land-based impact pile driving into the nearby water may have the potential to negatively affect marine life in Coos Bay, notably phocids, otariids, and fish.

Figure 1 shows a hydrographic chart of Coos Bay with the transect used for underwater noise modeling.

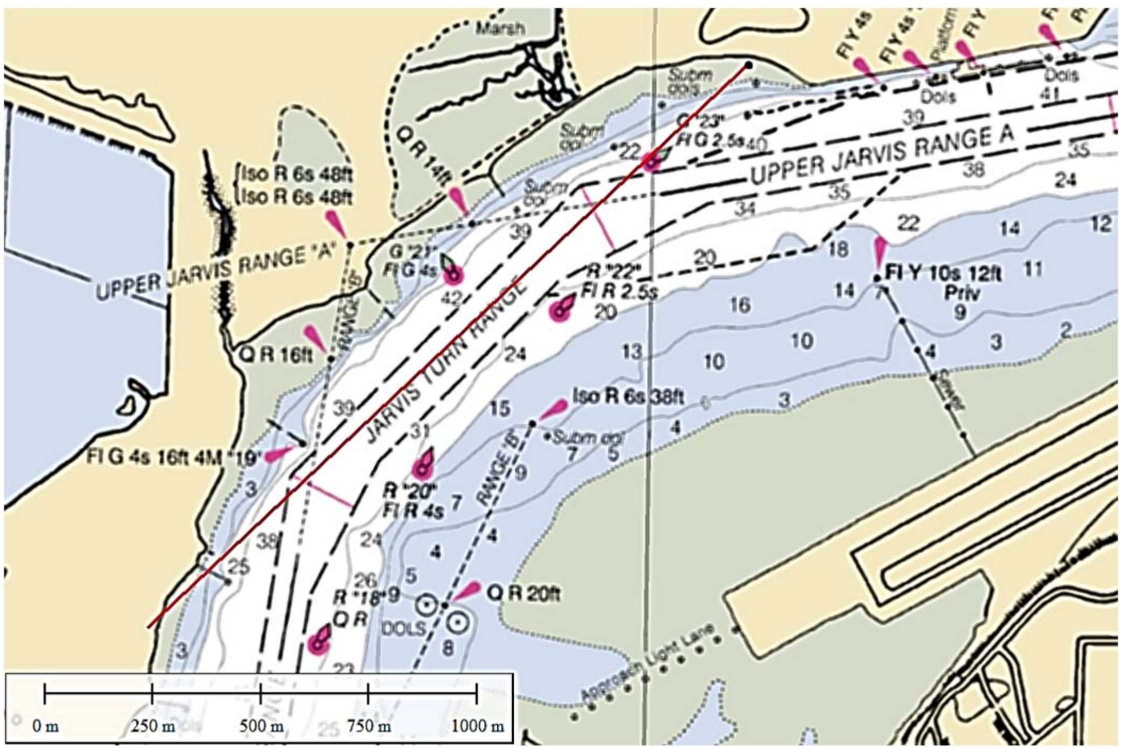

Figure 1. Annotated hydrographic chart of Coos Bay showing the modeling transect (red line) used in this report for assessing underwater noise from shore-based impact pile driving. The modeling transect follows a line-of-sight path originating at MOF and following the shipping channel in Coos Bay.

2. Acoustic Impact Criteria for Marine Mammals

It has been long recognized that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggest that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources NMFS (1998), ONR (1998), Nedwell and Turnpenny (1998), HESS (1999), Ellison and Stein (1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury (Section 2.1) and disturbance (Section 2.2). The following sections summarize the development of the current thresholds relevant to this study; this remains an active research topic, however.

2.1. Injury

The NMFS SPL criteria for injury to marine mammals from acoustic exposure were set according to recommendations for cautionary estimates of sound levels leading to onset of permanent hearing threshold shift (PTS). These criteria prescribed injury thresholds of 190 dB re 1 µPa SPL for pinnipeds and 180 dB re 1 µPa SPL for cetaceans, for all types of sound sources except tactical sonar and explosives (NMFS 2016). These injury thresholds are applied to individual noise pulses or instantaneous sound levels and do not consider the overall duration of the noise or its acoustic frequency distribution.

Criteria that do not account for exposure duration or noise spectra are generally insufficient on their own for assessing hearing injury. Human workplace noise assessment metrics consider the SPL as well as the duration of exposure and sound spectral characteristics. For example, the International Institute of Noise Control Engineering (I-INCE) and the Occupational Safety and Health Administration (OSHA) suggests thresholds in C-weighted peak pressure level and A-weighted time-average sound level (dB(A)[1] L_{eq}). They also suggest exchange rates that increase the allowable thresholds for each halving or doubling of exposure time. This approach assumes that hearing damage depends on the relative loudness perceived by the human ear, and that the ear might partially recover from past exposures, particularly if there are periods of quiet nested within the overall exposure.

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Members of this expert group published a landmark paper Southall et al. (2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: Low-, Mid- and High-Frequency Cetaceans (LFC, MFC, and HFC, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for humans; Section 4.1). SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it infers a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LFC and HFC, while retaining the filter shapes (Section 4.1). Their revised thresholds were based on TTS-onset levels in harbor porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HFC of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LFC on results obtained from MFC studies. In particular they

[1] The "A" refers to a specific frequency-dependent filter shaped according to a human equal loudness contour.

referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LFC of 192 dB re 1 µPa^2·s.

Also in 2012, the US Navy recommended a different set of criteria for assessing Navy operations (Finneran and Jenkins 2012). Their analysis incorporated new dolphin equal-loudness contours[2] to update weighting functions and injury thresholds for LFC, MFC, and HFC. They recommended separating the pinniped group into otariids (eared seals) and phocids (earless seals) and assigning adjusted frequency thresholds to the former based on several sensitivity studies (Schusterman et al. 1972, Moore and Schusterman 1987, Babushina et al. 1991, Kastak and Schusterman 1998, Kastelein et al. 2005, Mulsow and Reichmuth 2007, Mulsow et al. 2011a, Mulsow et al. 2011b).

Although a definitive approach is not yet apparent, there is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalized and promulgated technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). Table 1 provide the recommended thresholds, which are calculated for this project.

Table 1. Marine mammal injury (PTS onset) thresholds for impulsive sources based on NMFS (2016).

Hearing group	Impulsive source	
	Peak sound pressure level (dB re 1 µPa)	Weighted SEL (24 h) (dB re 1 µPa²s)
Low-frequency cetaceans	219	183
Mid-frequency cetaceans	230	185
High-frequency cetaceans	202	155
Phocid pinnipeds in water	218	185
Otariid pinnipeds in water	232	203

When the received SEL from an individual pile strike is below a certain level, called the effective quiet, the accumulated energy from multiple strikes does not contribute to injury regardless of the number of pile strikes. NMFS currently does not have an effective quiet threshold for marine mammals due to the lack of data (NMFS 2016).

2.2. Disturbance

The NMFS currently uses SPL thresholds for behavioral response of 160 dB re 1 µPa for impulsive sounds (NMFS 2016). As of 2016, NMFS applies these disturbance thresholds as a default, but makes exceptions on a species-specific and sub-population specific basis where warranted.

[2] An equal-loudness contour is the measured sound pressure level (dB re 1 µPa for underwater sounds) over frequency, for which a listener perceives a constant loudness when exposed to pure tones.

3. Acoustic Impact Criteria for Fish

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a NOAA panel two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- Temporary Threshold Shift (TTS).

Masking and behavioral effects are assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

This report applies the Popper et al. (2014) threshold criteria for the TTS based impairment of fish, exposed to impulse noise. All of the effects thresholds from Popper et al. (2014) are summarized in Table 2. In general, any adverse effects of impulse noise on fish behavior depends on the species, the state of the individuals exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to impulse noise, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulse noise to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a single pulse of a maximum received level of either 231 dB re 1 μPa (peak SPL) or 205 dB re 1 μPa^2·s (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

While it is evident that animals may adjust their behavior when they are exposed to pulsed sounds, there are few data appropriate to develop guidelines (Popper et al. 2014). Estimates of the behavioral responses should be conducted using the relative-risk criteria. The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, similar to the Southall et al. (2007) criteria for marine mammals.

When the received SEL from an individual pile strike is below a certain level, called the effective quiet, the accumulated energy from multiple strikes does not contribute to injury regardless of the number of pile strikes. NMFS currently considers the effective quiet threshold for fishes to correspond to a single-strike SEL of 150 dB re 1 μPa^{2}s. The zone of injury for fishes will therefore not exceed the distance to the 150 dB re 1 μPa^{2}s single-strike SEL threshold for pile driving.

Table 2. Criteria for pulsed noise exposure for fish and turtles adapted from Popper et al. (2014).

Type of animal	Mortality and potential mortal injury	Impairment			Behavior
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB 24 h SEL or > 213 dB peak	> 216 dB 24 h SEL or > 213 dB peak	>> 186 dB 24 h SEL	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB 24 h SEL or > 207 dB peak	203 dB 24 h SEL or > 207 dB peak	>> 186 dB 24 h SEL	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB 24 h SEL or > 207 dB peak	203 dB 24 h SEL or > 207 dB peak	186 dB 24 h SEL	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Turtles	210 dB 24 h SEL or > 207 dB peak	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish eggs and larvae	> 210 dB 24 h SEL or > 207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Peak pressure level dB re 1 μPa; 24 h SEL dB re 1μPa^2·s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

4. Methods

A full-wave numerical sound propagation model was used to simulate the transmission of impact pile driving noise through water-saturated soils into the water. Source levels for impact pile driving were calculated using a thin-shell structural vibration model for cylindrical piles. For modeling the sound propagation, JASCO collected environmental data that describes the bathymetry, water sound speed, and seabed geoacoustics in Coos Bay. The environmental data and source levels were input to underwater noise modeling software to estimate the underwater noise received levels (RL) that would be present in the water near the pile driving.

4.1. Bathymetry

A bathymetry grid for the acoustic propagation model was constructed from two datasets:

- U.S. Coastal Relief Model Digital Elevation Model (DEM) with a 3-arc-second resolution (NGDC 2017), and
- Coos Bay hydrographic chart, no. 18587, at 1:20,000 scale, from the National Oceanic and Atmospheric Administration (NOAA) Coast Survey (National Ocean Service Coast Survey 2017).

The DEM that we downloaded from the NOAA National Centers for Environmental Information (NCEI) website provided only positive elevation values inland of the Pacific Ocean coastline. To accurately represent the bathymetry of the Coos Bay Channel, 16433 spot bathymetry values were sampled from the NOAA bathymetric chart. These spot bathymetric readings are relative to mean lower low water (MLLW), while the DEM is relative to the mean high water (MHW) tidal level. Based on the tide information published on the Coos Bay hydrographic chart, we adjusted the spot bathymetry samples from the chart by 6 ft (1.8 m) before incorporating them into the revised DEM with a 9 m horizontal grid spacing. The underwater acoustic noise modeling was carried-out on the basis of a tidal water level equal to the MHW.

A bathymetry profile was extracted from the DEM along a single 226° radial (Figure 1). To simulate piles at different set-back distances, the bathymetry profile was manually adjusted to have 9.8 ft (3 m) and 98.4 ft (30 m) of land between the pile and the water. The bathymetry profile was also manually edited to add a dredged basin with a uniform bottom at 45 ft (13.7 m) depth from the toe of the sheet pile out to the shipping channel.

4.2. Sound Speed Profile

A uniform sound speed of 1500 meters per second (m/s) was assumed for the entire water column. This is a common laboratory reference value for speed of sound in seawater. Since the water depth in this modeling area is very shallow (less than 46 ft (14 m)) and located in an estuary, it is reasonable to assume that this water column is well mixed and the speed of sound is uniform with depth.

4.3. Geoacoustics

In shallow water environments, where there is increased interaction with the seafloor, the properties of the substrate have a large influence over the sound propagation. Geotechnical information of the project site reveals sand and silty sand sediments (KBJ 2017). The required parameters for modeling sound propagation are the density, compressional-wave speed, shear-wave speed, compressional-wave attenuation, and shear-wave attenuation. Table 3 presents the geoacoustic profile that represents these geological conditions.

Table 3. Geoacoustic properties as a function of depth, in meters below the seafloor (mbsf). Within an indicated depth range, the parameter varies linearly within the stated range. The compressional (P) wave is the primary wave. The shear (s) wave is the secondary wave.

Depth (mbsf)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–50	Silty sand	1.83	1680–1730	0.5	250	0.1
> 50			1730			

4.4. Source Level

Draft engineering designs describe the maximum pipe pile for construction as 104.8 ft (31.9 m) long, 36 in (0.9 m) diameter, and embedded to a maximum penetration depth of 99.8 ft (30.4 m). The construction plan calls for the piles to be driven using a Delmag D80-23 diesel impact hammer. A forcing function for the hammer was modeled using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010) assuming a strike energy corresponding to 65% of the hammer’s maximum rated energy of 228.15 kJ. Figure 2 presents the forcing function of the hammer at 65% and maximum energy; the latter was used in previous modeling phases of this project. The forcing function was computed assuming direct contact between the hammer and the piles (i.e., no cushion material).

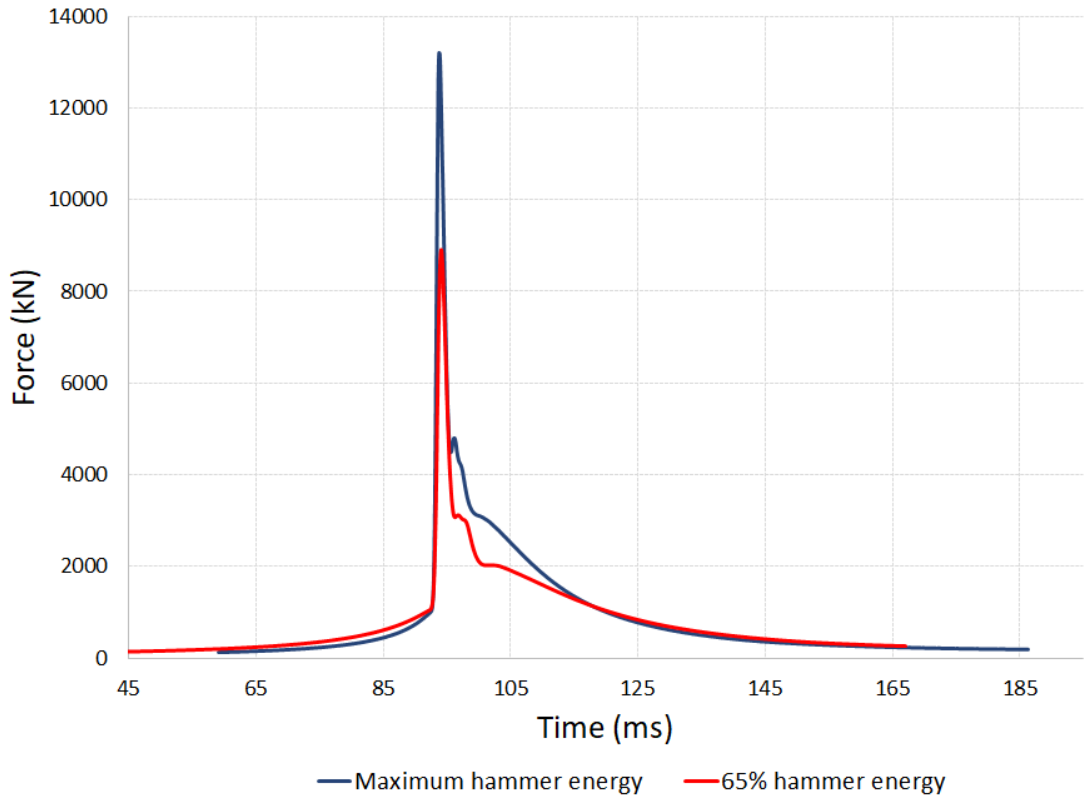

Figure 2. Force (kilonewtons (kN)) at the pile tip generated by a Delmag D80-23 diesel impact hammer as predicted by GRLWEAP 2010: 100% energy (blue), 65% energy (red).

A structural acoustic model of pile vibration and near-field sound radiation (MacGillivray 2014) was used to predict the vibration of a pile when struck (Figure 3). The sound radiating from the pile itself was simulated using a vertical array of discrete point sources to accurately characterize vertical directivity effects in the near-field zone. An extrapolation method (Zykov et al. 2016) was used to extend the modeled source levels up to 4 kHz, by applying a −2 dB per 1/3-octave-band roll-off coefficient to the source levels starting at 800 Hz.

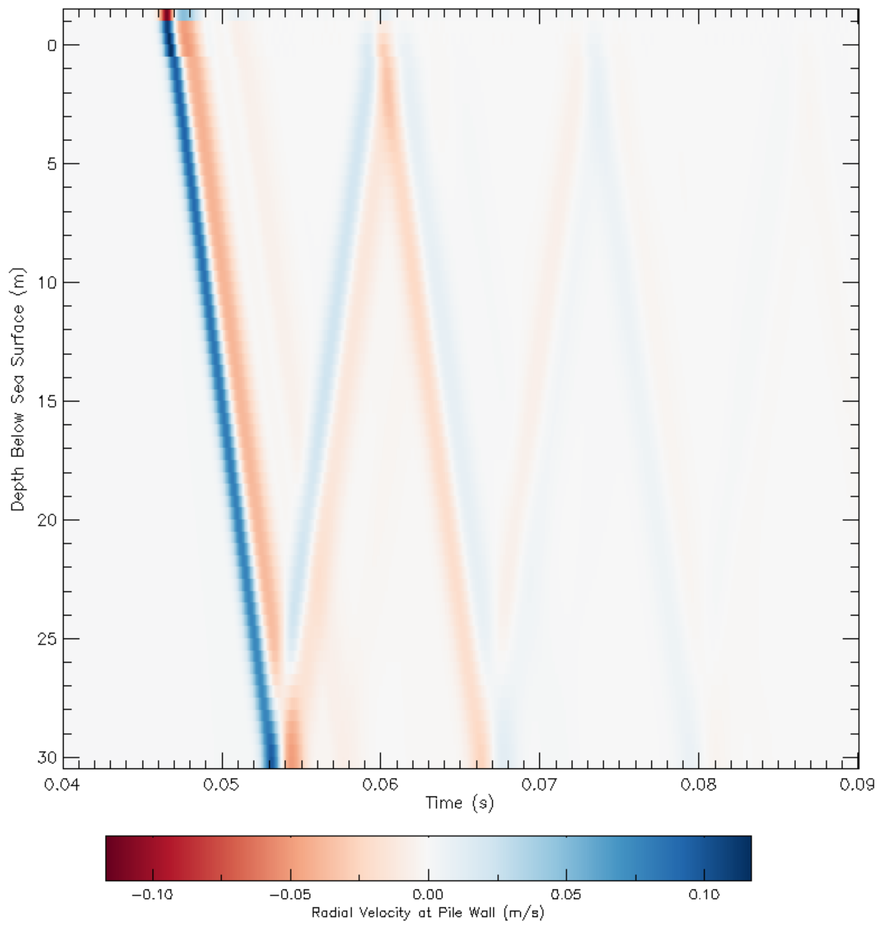

Figure 3. Radial vibration of the pile wall as predicted by the structural acoustic model.

4.5. Underwater Sound Propagation Model

For impulsive sounds from impact pile driving, time-domain representations of the pressure waves generated in the water are required for calculating sound pressure level (SPL), sound exposure level (SEL), and peak pressure level. For this study, synthetic pressure waveforms were computed using FWRAM, which is JASCO's time-domain acoustic propagation model. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, accounting for bathymetry, water sound speed profile, and seabed geoacoustics. FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

4.6. Transmission Loss Through Sheet Pile Wall

Frequency-dependent attenuation through the sheet pile wall at the Materials Offloading Facility (MOF) was calculated from the soil through a 0.5 inch (1.27 cm) steel layer according to a plane wave transmission model (Jensen et al. 2011). The frequency-dependent transmission loss (Figure 4) was applied to calculated source pressures of the pipe pile to simulate the attenuation of the pile driving noise due to the sheet pile wall.

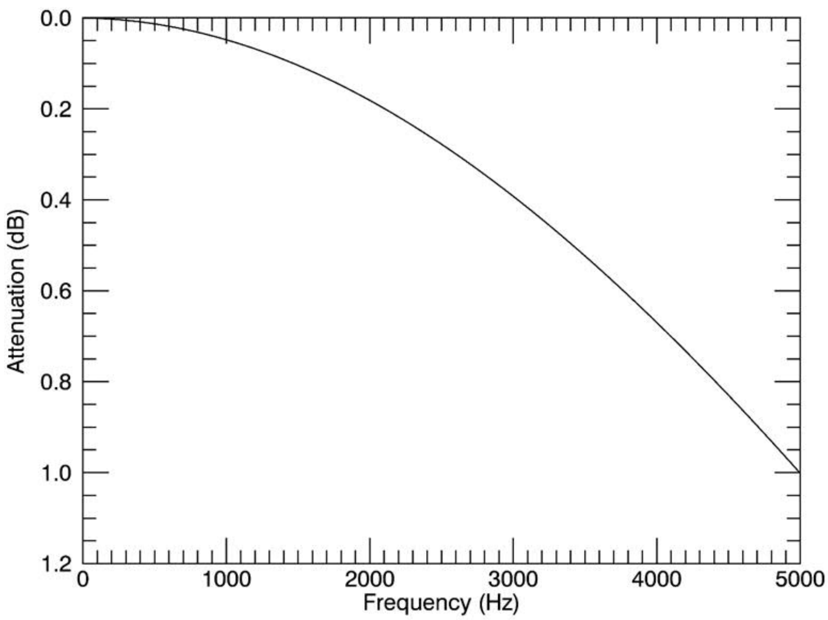

Figure 4. Calculated sound attenuation of the sheet pile wall versus frequency.

4.1. Marine Mammal Frequency Weighting Functions

In 2015, a U.S. Navy technical report recommended new auditory weighting functions for marine mammals (Finneran 2016). The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The report proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016). Figure 5 shows the recommended frequency-weighting curves.

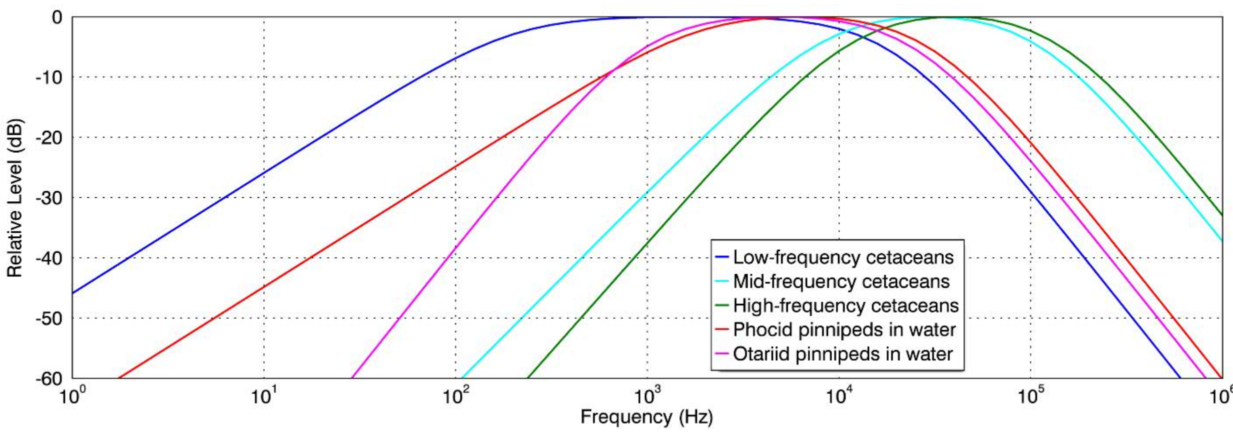

Figure 5. Auditory weighting functions for functional marine mammal hearing groups as recommended by NOAA 2016.

5. Results

The modeled received levels (RL) of the broadband noise in the water column generated by the impact pipe pile driving are shown in Figures 6 and 7. These figures show unweighted, per-pulse SEL (dB re 1 µPa^{2}s) as a function of the horizontal distance from the source, and the depth of the receiver, for the two modeling locations.

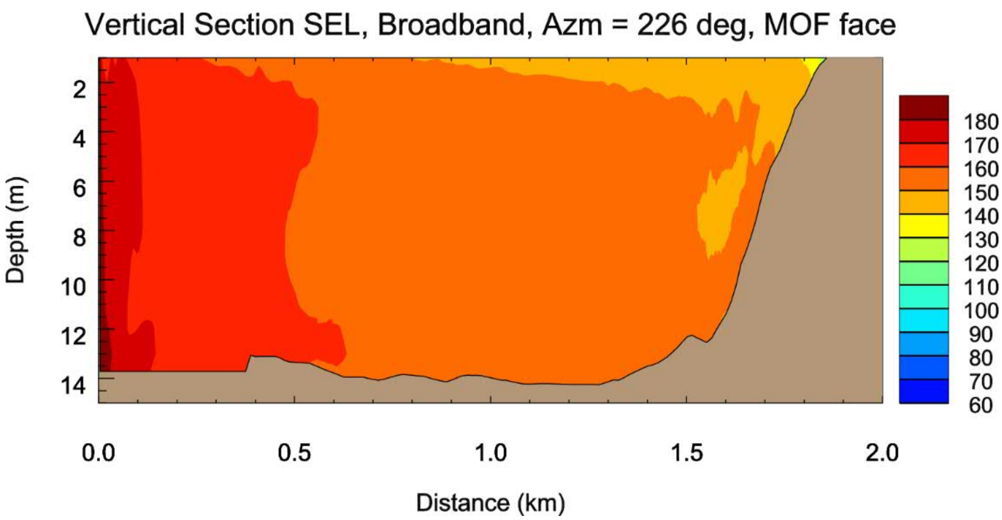

Figure 6. MOF: Per-pulse SEL (unweighted) versus horizontal range from the source and depth below the MHW tidal level.

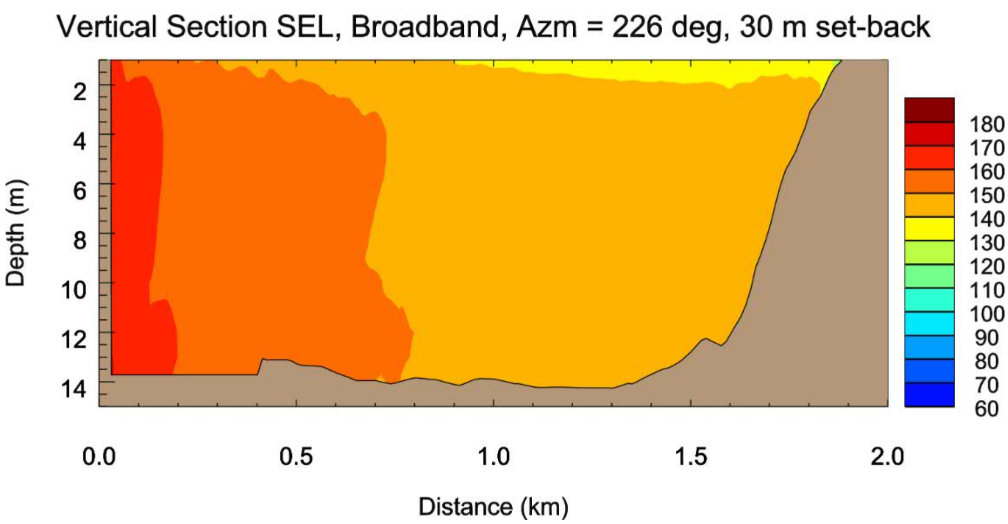

Figure 7. 30-m set-back: Per-pulse SEL (unweighted) versus horizontal range from the source and depth below the MHW tidal level.

The maximum modeled RL (over depth) as a function of range is shown in Figure 8 for the two modeling locations. Inspection of the 1/3-octave-band RL shows that highest levels are at frequencies ~300 to 500 Hz (Figure 9). These frequencies are within the hearing ranges of all marine mammal hearing groups, although killer whales (mid-frequency cetaceans) and harbor porpoises (high-frequency cetaceans) would not hear these frequencies as well as seals (phocid pinnipeds) and sea lions (otariid pinnipeds) (NMFS 2016).

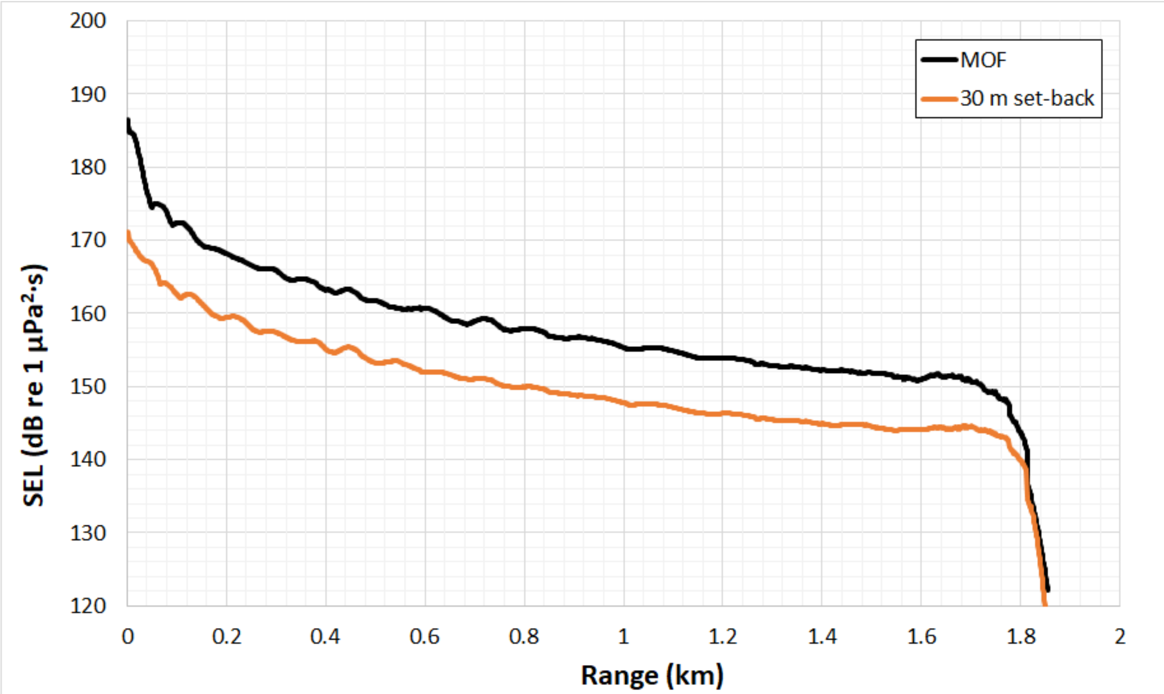

Figure 8. Maximum-over-depth per-pulse SEL (unweighted) versus horizontal range from the shoreline for both modeling locations.

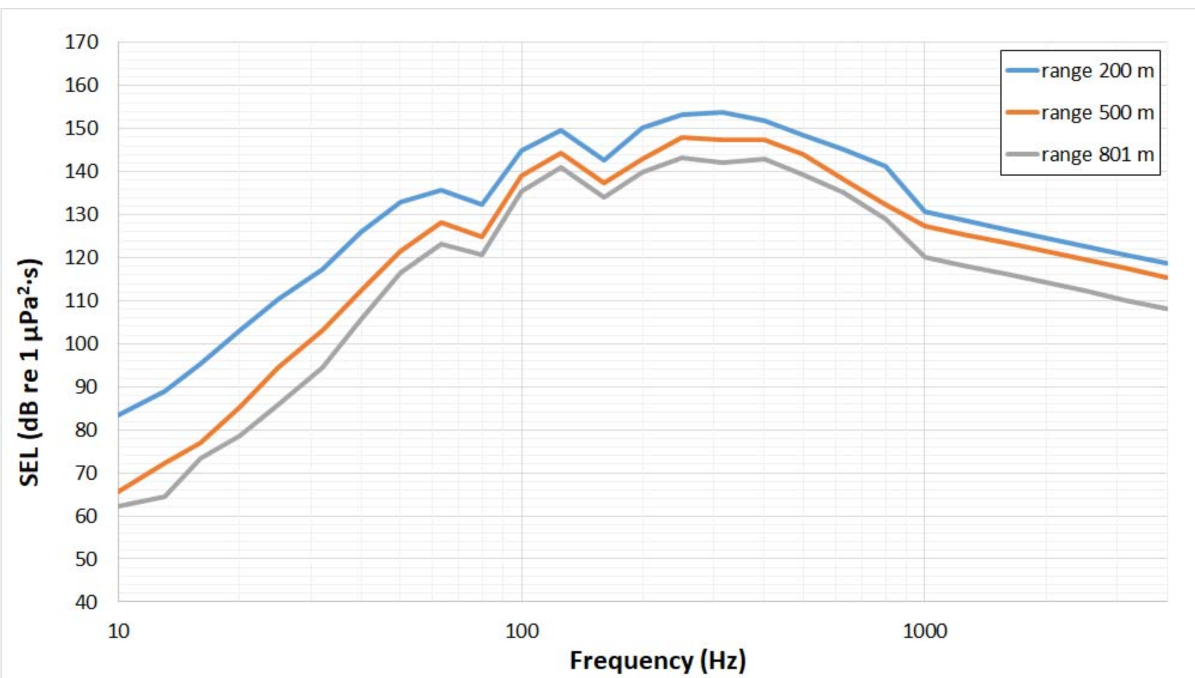

Figure 9. 30 m set-back: Maximum-over-depth per-pulse SEL versus frequency in 1/3-octave-bands at three different ranges from the shoreline.

6. Summary

NMFS (2016) criteria define a 160 dB re 1 µPa SPL (rms) behavioral threshold for marine mammals for impulsive sound sources. Table 4 shows the maximum distance to 160 dB re 1 µPa SPL at both piling locations (MOF and 30-m set-back). Peak sound pressure level thresholds for marine mammals and fish are presented in Tables 5 and 6, respectively.

Tables 7 to 10 show the distances from the shoreline to the SEL_{24h} thresholds for marine mammals and fish at both piling locations as per NMFS (2016) and FHWG (2008) and Popper et al. (2014) criteria. Because SEL_{24h} depends on the total number of hammer strikes over a 24-hour period, distances were calculated for two possible conditions: 10000 and 20000 strikes. Assuming a blow rate of 40 strikes/minute, these correspond to 250 and 500 total minutes of pile driving during a 24-hour period.

Comparing Phase 3 and 5 (same pile parameters but reduced hammer energy for Phase 5) sound levels at the shoreline from piling at the 30 m set-back location reveals a reduction of approximately 4 dB for the per-pulse unweighted SEL in Phase 5. Comparing Phase 2 and Phase 5 (increased pile length from 60 ft in Phase 2 to 104.8 ft in Phase 5 and reduction in hammer energy to 65% in Phase 5) sound levels at the shoreline from piling at the MOF face reveals a decrease of approximately 4.4 dB for the per-pulse unweighted SEL in Phase 5. Phase 2, 3 and 4 reports are attached as Appendices to this report.

For piling at the MOF face, per-pulse peak sound pressure level threshold radii were reduced on average by 43% from Phase 2 due to the 35% hammer energy reduction, even though the pile length was increased from 60 ft to 104.8 ft. The weighted SEL_{24h} marine mammal radii were reduced by approximately 45% on average (when the number of hammer strikes was unchanged) except where sound propagation was restricted by local bathymetry in Coos Bay.

For piling at the 30 m set-back location, the unweighted SEL_{24h} fish injury radii from piling were reduced on average by 57% from Phase 4, solely due to the 35% reduction in hammer energy (fish injury radii were not modelled at the MOF face for Phase 4). The Phase 5 fish injury radii for 20000 strikes were also smaller than the Phase 4 10000 strike radii by an average of 25% due to the reduction in hammer energy.

Table 4. Maximum modeled distance to 160 dB re 1 µPa behavioral threshold for marine mammals for the two modeling locations.

Modeling location	Maximum range to 160 dB re 1 µPa (m)
MOF	1797
30-m set-back	1796*

* Note that the 160 dB re 1 µPa threshold is crossed twice for the 30-m set-back location (at 1109 m and 1796 m), due to local bathymetry. The range reported in the table is the greater of the two distances.

Table 5 Maximum range from the shoreline of piling at both locations to modeled peak pressure level TTS and PTS thresholds based on the NOAA Technical Guidance (NMFS 2016) for marine mammals. A dash indicates that the threshold was not reached.

Hearing group	Peak sound pressure level (dB re 1 µPa)			
	PTS Threshold	Range (m)	TTS Threshold	Range (m)
Piling at MOF				
Low-frequency cetaceans	219	-	213	17
Mid-frequency cetaceans	230	-	224	-
High-frequency cetaceans	202	112	196	213
Phocid pinnipeds in water	218	-	212	26
Otariid pinnipeds in water	232	-	226	-
Piling at 30 m setback				
Low-frequency cetaceans	219	-	213	-
Mid-frequency cetaceans	230	-	224	-
High-frequency cetaceans	202	-	196	51
Phocid pinnipeds in water	218	-	212	-
Otariid pinnipeds in water	232	-	226	-

Table 6. Maximum range from the shoreline of piling at the MOF to modeled peak pressure fish injury thresholds based on FHWG (2008) and Popper et al. (2014).

Threshold criteria	Peak sound pressure level (dB re 1 µPa)	Range (m)
FHWG 2008	206	37
Popper et al. (2014)	213	17
Popper et al. (2014)	207	37

Table 7. MOF: Maximum range from the shoreline to modeled 24h SEL thresholds based on the NOAA Technical Guidance NMFS 2016 for marine mammals. A dash indicates that the threshold was not reached.

Hearing group	Weighted SEL_{24h} (dB re 1 µPa²·s)			
	PTS Threshold	Range (m)	TTS Threshold	Range (m)
10000 strikes (250 minutes)				
Low-frequency cetaceans	183	1795	168	1841
Mid-frequency cetaceans	185	23	170	228
High-frequency cetaceans	155	588	140	1721
Phocid pinnipeds in water	185	830	170	1801
Otariid pinnipeds in water	203	38	188	509
20000 strikes (500 minutes)				
Low-frequency cetaceans	183	1813	168	1849
Mid-frequency cetaceans	185	32	170	385
High-frequency cetaceans	155	799	140	1777
Phocid pinnipeds in water	185	1095	170	1813
Otariid pinnipeds in water	203	68	188	680

Table 8. 30-m set-back: Maximum range from the shoreline to modeled 24h SEL thresholds based on the NOAA Technical Guidance NMFS 2016 for marine mammals. A dash indicates that the threshold was not reached.

Hearing group	Weighted SEL_{24h} (dB re 1 µPa²·s)			
	PTS Threshold	Range (m)	TTS Threshold	Range (m)
10000 strikes (250 minutes)				
Low-frequency cetaceans	183	1481	168	1835
Mid-frequency cetaceans	185	-	170	-
High-frequency cetaceans	155	29	140	612
Phocid pinnipeds in water	185	223	170	1712
Otariid pinnipeds in water	203	-	188	63
20000 strikes (500 minutes)				
Low-frequency cetaceans	183	1785	168	1841
Mid-frequency cetaceans	185	-	170	19
High-frequency cetaceans	155	65	140	912
Phocid pinnipeds in water	185	383	170	1804
Otariid pinnipeds in water	203	-	188	142

Table 9. MOF: Maximum range from the shoreline to modeled SEL_{24h} fish injury thresholds based on FHWG 2008 and Popper et al. (2014). See Section 2 for details on Popper et al. (2014) criteria.

Source	SEL_{24h}		
	Criteria	dB re 1 µPa²s	Range (m)
10000 strikes (250 min)			
FHWG 2008	Injury (fish ≥2 g)	187	1723*
	Injury (fish <2 g)	183	1723*
Popper et al. (2014)	Mortality and potential mortal injury	219	33
	Recoverable injury	216	43
	Mortality and potential mortal injury	210	142
	Mortality and potential mortal injury	207	240
	Recoverable injury	203	457
	TTS	186	1723*
20000 strikes (500 min)			
FHWG 2008	Injury (fish ≥2 g)	187	1723*
	Injury (fish <2 g)	183	1723*
Popper et al. (2014)	Mortality and potential mortal injury	219	43
	Recoverable injury	216	85
	Mortality and potential mortal injury	210	240
	Mortality and potential mortal injury	207	383
	Recoverable injury	203	630
	TTS	186	1723*

* Range limited by the distance to the effective quiet threshold of 150 dB re 1 µPa²s single-strike SEL.

Table 10. 30-m set-back: Maximum range from the shoreline to modeled SEL_{24h} fish injury thresholds based on FHWG 2008 and Popper et al. (2014). See Section 2 for details on Popper et al. (2014) criteria. A dash indicates that the threshold was not reached.

Source	SEL_{24h}		
	Criteria	dB re 1 µPa²s	Range (m)
	10000 strikes (250 min)		
FHWG 2008	Injury (fish ≥2 g)	187	881*
	Injury (fish <2 g)	183	881*
Popper et al. (2014)	Mortality and potential mortal injury	219	-
	Recoverable injury	216	-
	Mortality and potential mortal injury	210	6
	Mortality and potential mortal injury	207	46
	Recoverable injury	203	96
	TTS	186	881*
	20000 strikes (500 min)		
FHWG 2008	Injury (fish ≥2 g)	187	881*
	Injury (fish <2 g)	183	881*
Popper et al. (2014)	Mortality and potential mortal injury	219	-
	Recoverable injury	216	-
	Mortality and potential mortal injury	210	46
	Mortality and potential mortal injury	207	82
	Recoverable injury	203	170
	TTS	186	881*

* Range limited by the distance to the effective quiet threshold of 150 dB re 1 µPa²s single-strike SEL.

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Glossary

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands comprise one octave. One-third-octave-bands become wider with increasing frequency. Also see octave.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

broadband sound level/broadband noise
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power ANSI S1.1-1994 R2004.

digital elevation model (DEM)
A sampled array of elevations (and bathymetric depths in water) for a number of geographical positions at regularly spaced horizontal intervals (i.e., on a horizontal grid).

effective quiet
The maximum sound pressure level that will fail to produce any significant temporary shift in hearing despite duration of exposure and amount of accumulation.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

geoacoustic
Relating to the acoustic properties of the seabed.

hertz (Hz)
A unit of frequency defined as one cycle per second.

mbsf
Meters below sea floor.

mean high water (MHW)
The arithmetic mean of all the high-water heights observed over a period of several years. In the United States this period spans 19 years and is referred to as the National Tidal Datum Epoch.

mean lower low water (MLLW)
The arithmetic mean of the lower of the two low water heights of each tidal day, observed over a period of several years. In the United States this period spans 19 years and is referred to as the National Tidal Datum Epoch.

MOF
Materials Offloading Facility.

NCEI
National Centers for Environmental Information (formerly the National Geophysical Data Center).

NGDC
National Geophysical Data Center.

NOAA
National Oceanic and Atmospheric Administration.

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

point source
A source that radiates sound as if from a single point ANSI S1.1-1994 R2004.

pressure (acoustic)
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

PTS
Permanent (hearing) threshold shift

received level
The sound level measured at a receiver.

rms
root-mean-square.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound
A time-varying pressure disturbance generated by mechanical vibration waves traveling through a fluid medium such as air or water.

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure ANSI S1.1-1994 R2004.

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 μPa) and the unit for SPL is dB re 1 μPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2 / p_0^2\right) = 20\log_{10}\left(p / p_0\right) .$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 meter from the acoustic center of the source. Unit: dB re 1 μPa @ 1 m (sound pressure level) or dB re 1 $\mu Pa^2 \cdot s$ (sound exposure level).

TTS
Temporary (hearing) threshold shift.

Appendix D: JASCO Technical Memorandum, Jordan Cove Vibratory Pile Driving Underwater Noise Modeling, Sheet pile Installation Modeling, Phase 1, February 21, 2017

Jordan Cove Vibratory Pile Driving Underwater Noise Modeling

Technical Memorandum

Submitted to: William Gorham, Ph.D.
AECOM Environment
Contract: 86019

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

1. Introduction

This technical memorandum presents results from an underwater noise modeling study undertaken by JASCO on behalf of AECOM to support a Marine Mammal Protection Act Incidental Harassment Authorization application. The planned noise-generating activity is "in the dry" vibratory sheet pile installation that will be conducted as part of the construction of a Materials Off-loading Facility (MOF) at the proposed Jordon Cove LNG Terminal at Coos Bay, Oregon. The modeling presented in this technical memorandum is based on draft engineering plans for the Jordan Cove facility and is intended to provide a screening-level assessment of potential underwater noise from sheet-pile wall construction at the MOF.

The draft construction plans call for a 30-feet wide soil berm to be installed between the water and the location of the sheet piles. The sheet piles will be installed behind the berm prior to excavation of a marine slip at the proposed facility. The purpose of the present study is to model underwater noise that would be transmitted from the sheet piles to the water, through the soils, during vibratory driving. Noise from sheet pile driving may have the potential to negatively impact nearby marine mammals in Coos Bay. The impacts of underwater noise generated by vibratory pile driving at the MOF is expected to be mainly limited to harbor seals that may be foraging near or transiting past the construction site, though other species of marine mammals may occasionally be present.

A hydrographic chart of Coos Bay is shown in Figure 1, with the location of the proposed sheet pile wall and the two transects used for underwater noise modelling in this study.

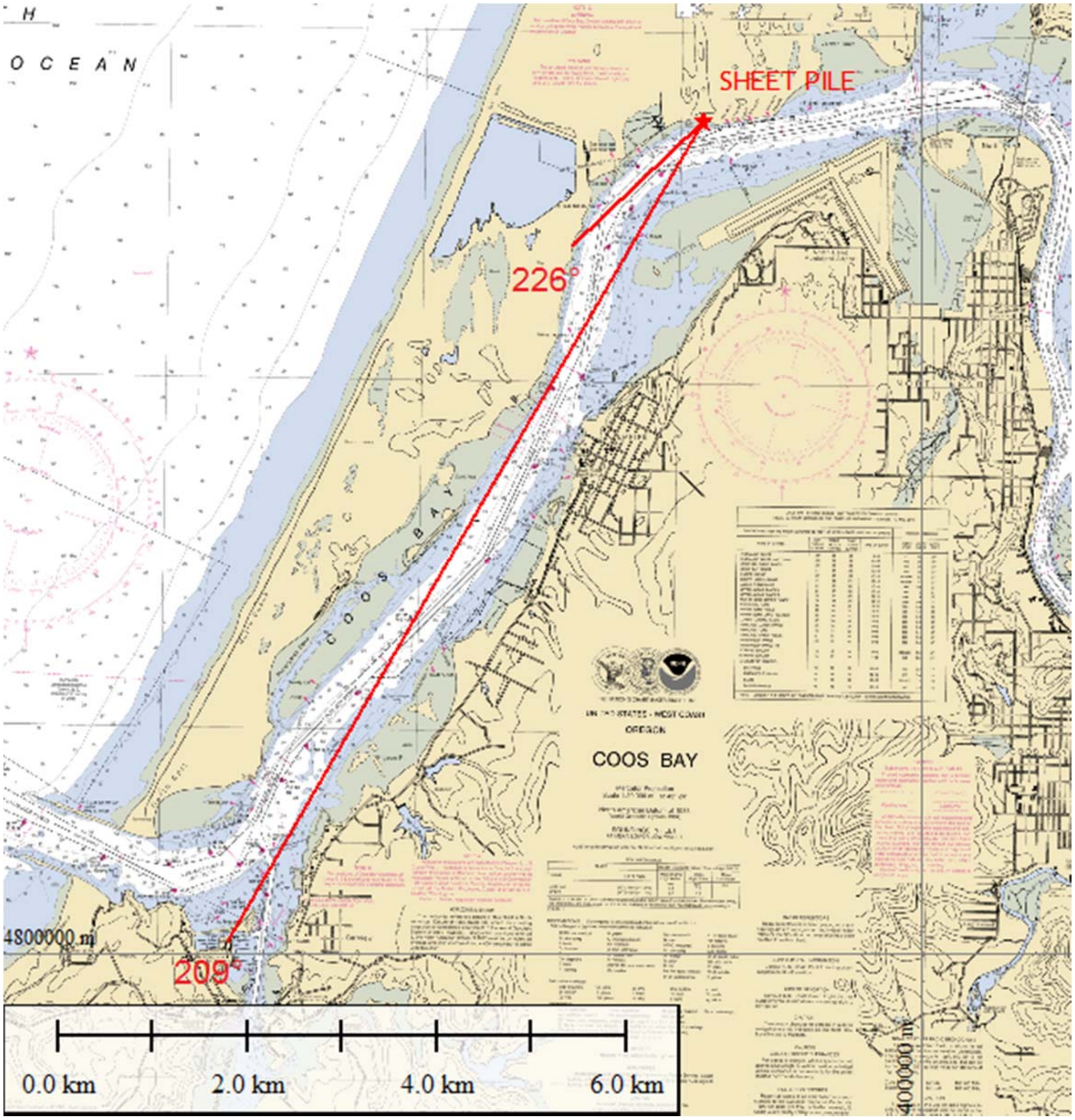

Figure 1. Annotated hydrographic chart of Coos Bay showing the location of the proposed sheet pile driving (red star) and the underwater noise modelling transects (red lines). An expanded distance scale is also provided.

2. Methods

A numerical sound propagation model was used to simulate the transmission of sheet piling noise through water-saturated soils into water. Source levels for this activity were based on published hydrophone measurements of in-water sheet pile driving. To translate the source levels from water into soil, it was assumed that the sheet piles would generate the same magnitude of vibration in soil as in water.

For modeling the sound propagation, JASCO collected environmental data describing the bathymetry, water sound speed, and seabed geoacoustics in Coos Bay. The environmental data and source levels were input to underwater noise modelling software to estimate the underwater noise received levels (RL) that would be present in the water near the pile driving.

2.1. Bathymetry

A bathymetry grid for the acoustic propagation model was constructed based on two datasets:

- U.S. Coastal Relief Model digital elevation model (DEM) with a 3-arc-second resolution (National Centers for Environmental Information, 2017)
- Coos Bay hydrographic chart, no. 18587, at 1:20,000 scale, from the Coast Survey, National Ocean Service, NOAA. (Coast Survey, 2017).

The DEM downloaded from the NCEI website provided only positive elevation values inland of the Pacific Ocean coastline. To accurately represent the bathymetry of the Coos Bay channel, 16433 spot bathymetry values were sampled from the NOAA Bathymetric Chart. These spot bathymetric readings are relative to Mean Lower Low Water (MLLW), while the DEM is relative to the mean high water (MHW) tidal level. Based on the tide information published on the Coos Bay hydrographic chart, an adjustment of 6 feet was made to the spot bathymetry samples from the chart before incorporating them into the revised DEM.

The depth/elevations from the NCEI DEM and the spot bathymetry samples from the NOAA hydrographic chart were combined into a new DEM with a 9-meter horizontal grid spacing. The underwater acoustic noise modelling has been carried-out on the basis of a tidal water level equal to the mean high water (MHW). On the basis of NOAA tidal data, this water level has been taken to be 6 feet higher than the mean lower low water (MLLW) level, which is the basis for the depth soundings and depth contours portrayed on the NOAA hydrographic charts (Coast Survey, 2017).

2.2. Sound Speed Profile

For this particular study, a uniform sound speed of 1500 m/s was assumed for the entire water column. This is a common laboratory reference value for speed of sound in sea-water. Since the water depth in this modelling area is very shallow (less than 14 m), and located in an estuary, it is reasonable to assume that that water column is well mixed and that that the speed of sound is uniform with depth.

2.3. Geoacoustics

In shallow water environments where there is increased interaction with the sea-floor, the properties of the substrate have a large influence over the sound propagation. Information on the composition of the soils at the measurement site was not available at the time of writing, therefore the geoacoustic model used in this work is based on estimated values that are thought to be typical for this environment, consisting of soft silty sand sediments of undetermined depth. The required parameters for modelling sound propagation are the density (ρ), compressional-wave speed, (c_p), shear-wave speed (c_s), compressional-wave attenuation (α_p), and shear-wave attenuation (α_s). A geoacoustic profile, Table 1, has been constructed to represent these geological conditions.

Table 1. Geoacoustic properties as a function of depth, in metres below the seafloor (mbsf). Within an indicated depth range, the parameter varies linearly within the stated range.

Depth (mbsf)	Material	Density (g/cm³)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–50	Silty sand	1.83	1680–1730	0.5	250	0.1
> 50			1730			

2.4. Source Level

Based on the draft engineering designs, it was assumed that individual sheet piles were 50 feet tall and 18 inches wide, embedded to a maximum penetration depth of 36 feet below MHW. For the purpose of this study, we assumed that the underwater noise of vibratory driving of the pile can be modelled as a point source located at the midpoint of the underground portion of the pile. Therefore, we used a source depth of 5.48 meters (i.e., 18 feet below MHW).

The source level (SL) spectrum of the vibratory driving of this pile for the purpose of this study was assumed to be equivalent to the SL spectrum reported for Berth 23, Port of Oakland (APE 400 3200 kN vibe hammer) vibratory pile driving (Buehler, et al., 2016). The SL, in terms of sound pressure level (SPL) at 1 meter from the source location, in 1/3-octave bands, was taken to be as shown in Table 2.

Table 2. SL of vibratory pile driving, in terms of SPL band-level at 1 meter from the source location, in 1/3-octave bands.

Frequency (Hz)	10	13	16	20	25	32	40	50	63	80	100	125	160	200
SL (dB re 1 µPa)	136.8	138.2	139.6	141.0	149.7	146.4	141.1	140.5	146.1	149.3	146.1	154.2	153.7	157.1

Frequency (Hz)	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
SL (dB re 1 µPa)	158.9	156.1	158.4	160.4	165.3	171.1	174.2	170.8	172.0	170.9	166.9	163.8	162.6

2.5. Underwater Acoustic Propagation Model

The underwater acoustic propagation modeling for this study was performed using a modified version of the RAM parabolic-equation model (Collins 1993, 1996), that has been enhanced by JASCO. RAM was developed at the US Naval Research Laboratory has been extensively benchmarked and is widely used as a reference model in the underwater acoustics community.

3. Results

The modeled received level (RL) of the broadband noise in the water column generated by the vibration sheet pile driving is illustrated in Figure 2 and Figure 3, which show the sound pressure level (SPL) in dB re 1 µPa in areas of different color as a function of the horizontal distance from the source (range) and the depth of the receiver. Each of the figures is for a different azimuthal direction away from the source location (measured in degrees, clockwise from geographic true north).

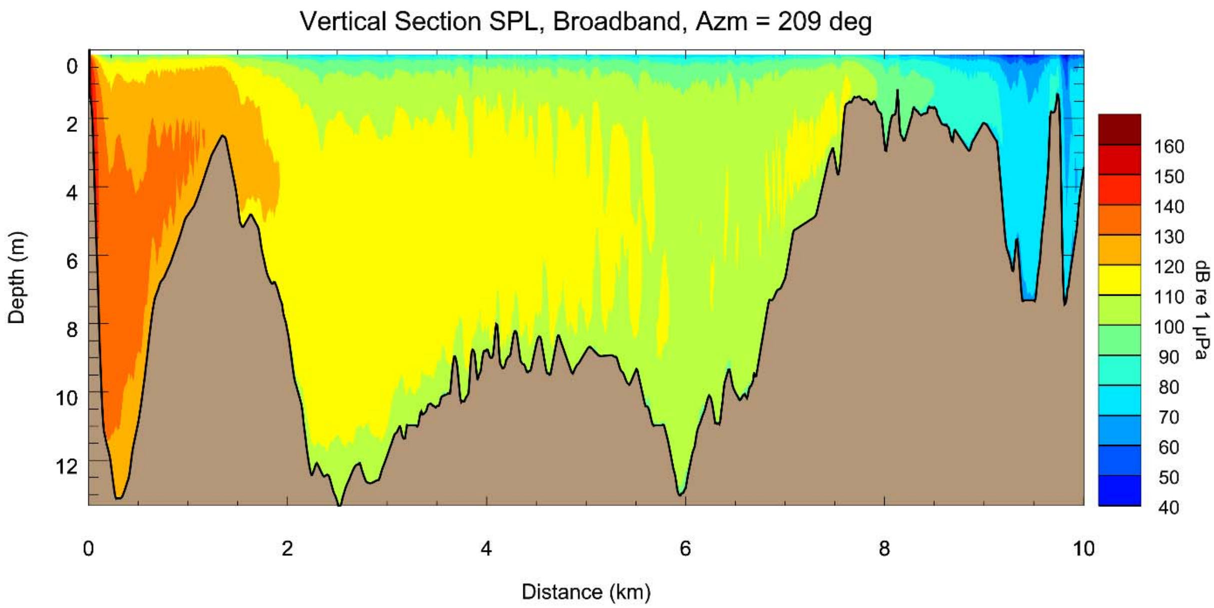

Figure 2. Broadband SPL versus horizontal range from the source and depth below the MHW tidal level for the 209° azimuth.

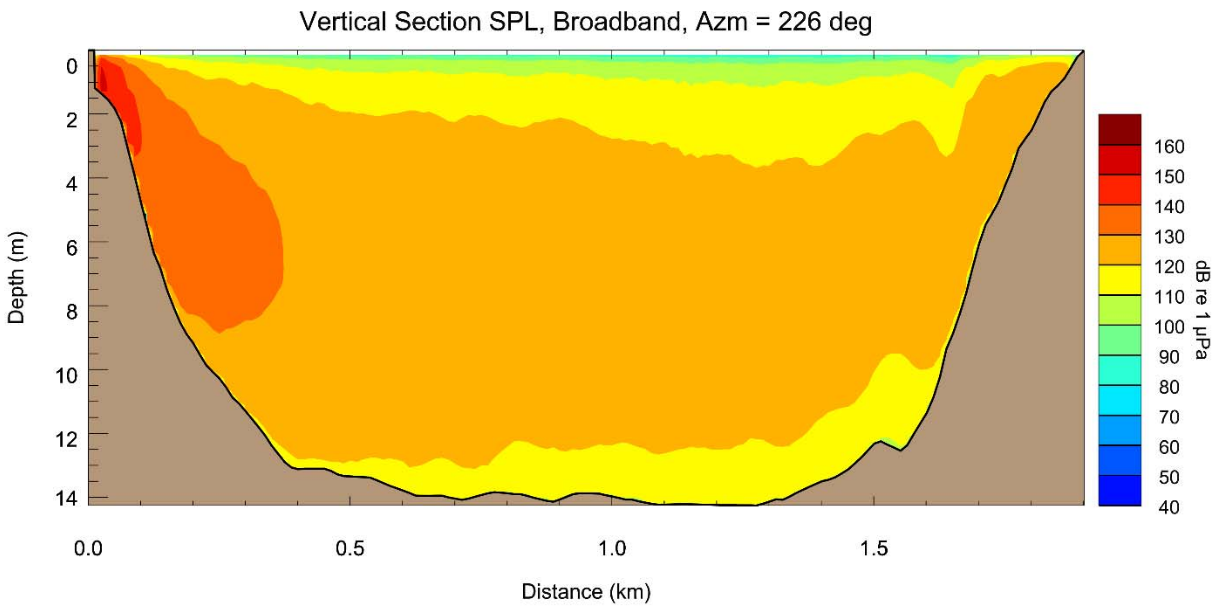

Figure 3. Broadband SPL versus horizontal range from the source and depth below the MHW tidal level for the 226° azimuth.

The 209° azimuthal direction illustrates the longest possible underwater range of noise propagation from the source location, as other directions are blocked at shorter ranges by shoals or the shoreline. The 226° azimuthal direction illustrates the highest underwater RL, at longer ranges, due to the greater water depth in that direction before shoaling is encountered.

The maximum modelled RL (over depth) as a function of range is illustrated in Figure 4 and Figure 5 for the same two azimuthal directions as the previous figures. Inspection of the 1/3-octave band RL shows that highest levels are at frequencies around 1000 Hz (Figure 6).

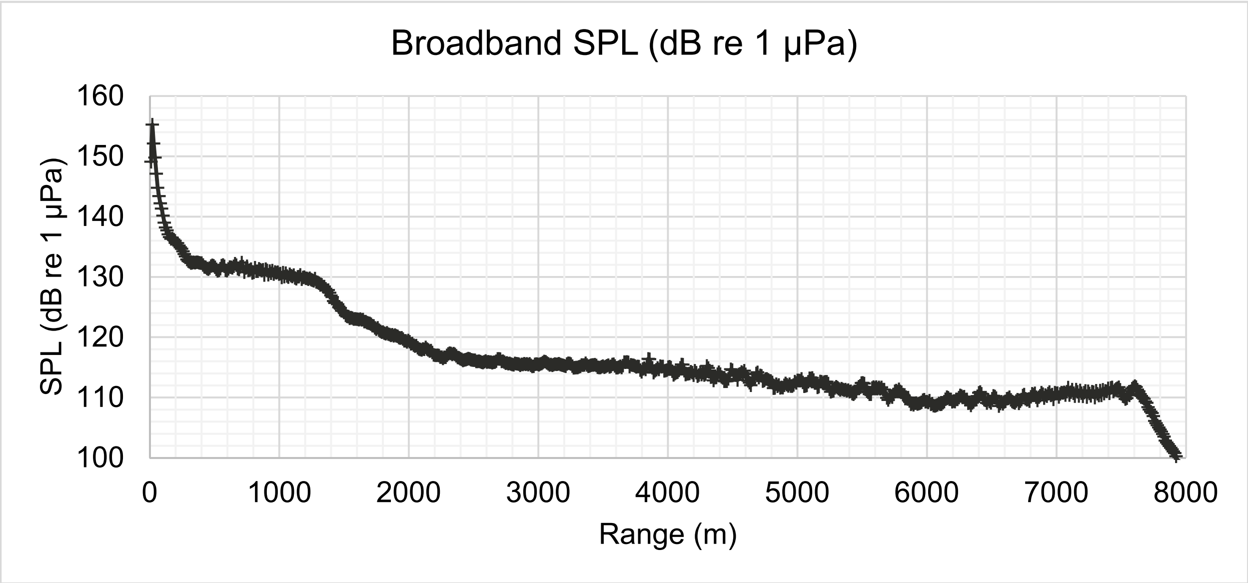

Figure 4. Maximum-over-depth broadband RL versus horizontal range from the source for the 209° azimuth.

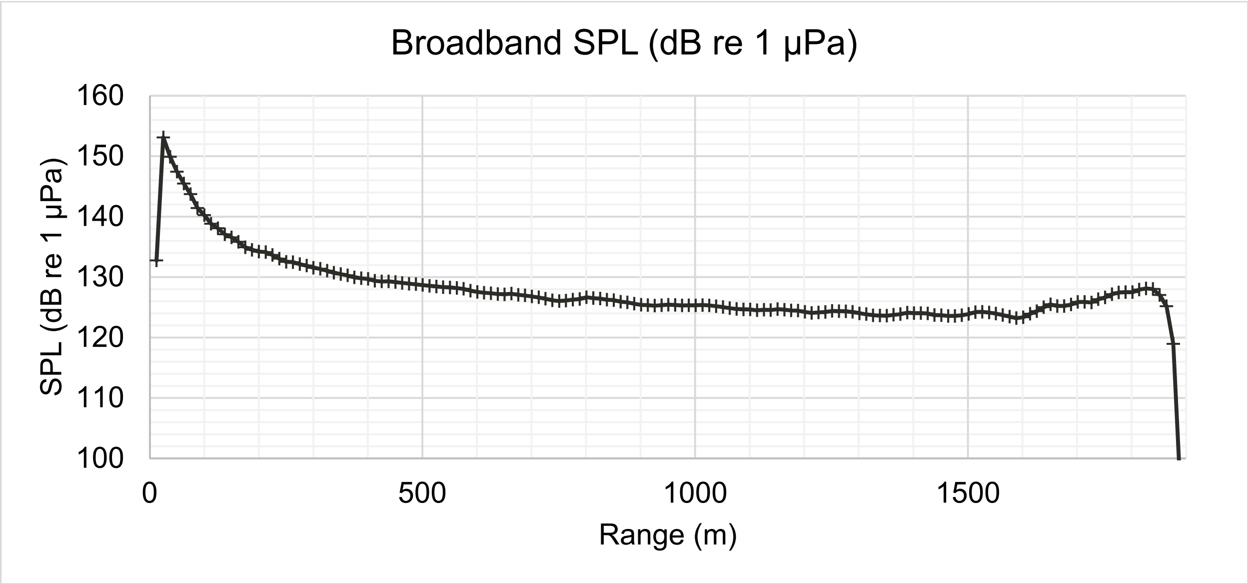

Figure 5. Maximum-over-depth broadband RL versus horizontal range from the source for the 226° azimuth.

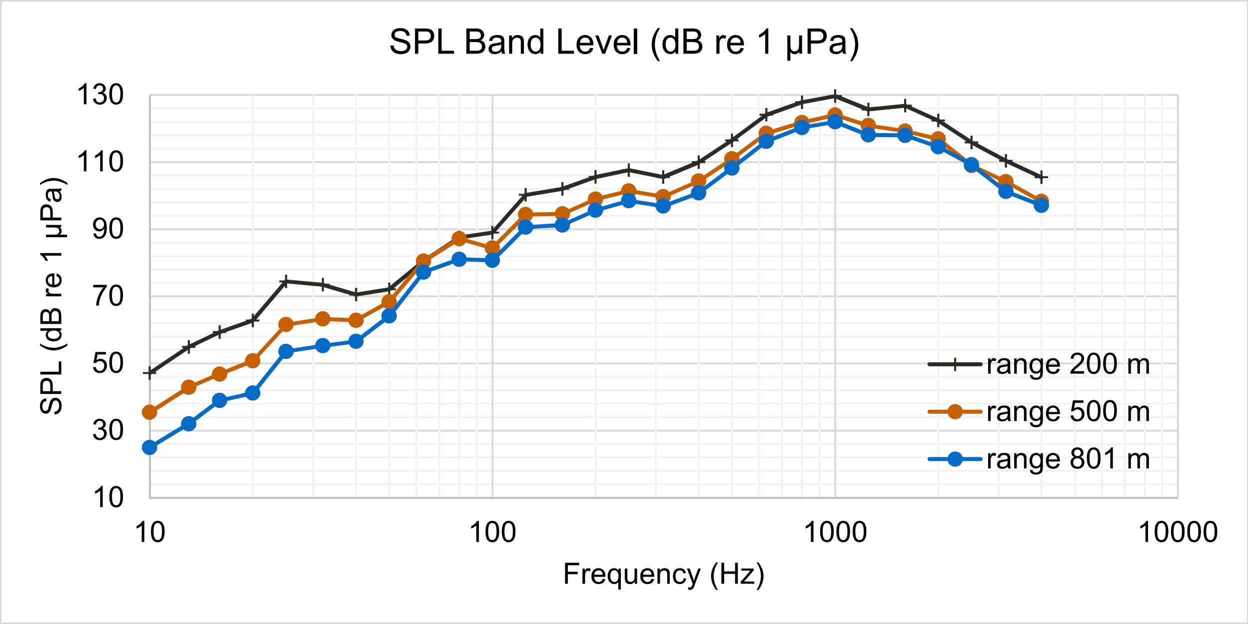

Figure 6. Maximum-over-depth SPL versus frequency in 1/3-octave bands, at three different distances, for the 226° azimuth.

4. Summary

Table 3 shows the maximum distance to the 120 dB re 1 μPa threshold along the two modelling transects considered in the current study. These results show that the highest noise levels from sheet piling at the MOF are to be found where the sound is able to propagate away from the source in deeper water for the furthest distance, before being attenuated by bottom loss in shallower water.

Table 3. Maximum modeled distance to the 120 dB re 1 μPa threshold along two azimuths.

Azimuth (° CW from North)	Maximum range to 120 dB re 1 μPa (m)
209	1914
226	1870

Literature Cited

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Glossary

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands comprise one octave. One-third-octave-bands become wider with increasing frequency. Also see octave.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

digital elevation model (DEM)
A sampled array of elevations (and bathymetric depths in water) for a number of geographical positions at regularly spaced horizontal intervals (i.e., on a horizontal grid).

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

geoacoustic
Relating to the acoustic properties of the seabed.

hertz (Hz)
A unit of frequency defined as one cycle per second.

mbsf
Meters below sea floor

mean high water (MHW)
The arithmetic mean of all the high water heights observed over a period of several years. In the United States this period spans 19 years and is referred to as the National Tidal Datum Epoch.

mean lower low water (MLLW)
The arithmetic mean of the lower of the two low water heights of each tidal day, observed over a period of several years. In the United States this period spans 19 years and is referred to as the National Tidal Datum Epoch.

NCEI
National Centers for Environmental Information (formerly the National Geophysical Data Center).

NGDC
National Geophysical Data Center.

NOAA
National Oceanic and Atmospheric Administration.

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

parabolic equation method
A computationally-efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

received level
The sound level measured at a receiver.

rms
root-mean-square.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2/p_0^2\right) = 20\log_{10}\left(p/p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 meter from the acoustic center of the source. Unit: dB re 1 µPa @ 1 m (sound pressure level) or dB re 1 $\mu Pa^2 \cdot s$ (sound exposure level).

Appendix E: Marine Mammal Monitoring Plan, Jordan Cove Energy Project

Marine Mammal Monitoring Plan Jordan Cove Energy Project for Year 1 Construction

Docket No. CP17-495-000

October 2019

Prepared for:

Jordan Cove Energy Project, LP
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Table of Contents

DEFINITIONS/ACRONYMS

Pile Driving – Installing a pile into the ground, either above or below water, using an impact or vibratory pile driver.

Take - Defined under the Marine Mammal Protection Act (MMPA) as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. 1362) and further defined by regulation (50 CFR 216.3) as "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal.

Incidental Taking - An unintentional, but not unexpected, taking of a protected species. Incidental taking can be in the form of Level A harassment or Level B harassment.

Level A Harassment - Has the potential to injure a marine mammal or marine mammal stock in the wild.

Level B Harassment - Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

IHA – Incidental Harassment Authorization

MMPA – Marine Mammal Protection Act

Marine Mammal Monitoring Plan

Year 1 Construction Season
Jordan Cove Energy Project

Marine mammal monitoring will be implemented during certain construction activities related to the LNG Terminal and Ancillary Activities, as detailed in this Marine Mammal Monitoring Plan (Plan). Additional details on the specific activities referenced here and the project as a whole, are contained in the Incidental Harassment Authorization application. This plan is tailored for the pile driving activities that are scheduled to occur in the 2020–2021 construction season (Year 1) of project construction, as described in Section 2.

1.0 PURPOSE OF THE MONITORING PLAN

The purpose of this Plan is to establish procedures to ensure compliance with the National Marine Fisheries Service (NMFS) Incidental Harassment Authorization (IHA) requirements, thereby recording take of marine mammals as authorized, and enforcing shutdown zones as needed to avoid unauthorized take. Serious injury or lethal take of marine mammals is not expected to occur as a during construction of the LNG Terminal or Ancillary Activities. This plan is tailored for the pile driving activities that are scheduled to occur in the 2020–2021 construction season (Year 1) of project construction, as described in Section 2.

The objectives of the monitoring plan are to document measures to be implemented in planning and throughout Year 1 of the construction season to:

- Monitor site locations for the disturbance of marine mammals during construction activities that may result in incidental harassment;
- Avoid Level A harassment of marine mammals through visual monitoring of shutdown zones (e.g., zones where Level A harassment criteria may be exceeded) and implementing stop-work procedures if animals are detected in their respective shutdown zones;
- Record Level B harassment of multiple marine mammal species to ensure that the authorized amount is not exceeded; and
- Ensure that coordination with an acoustic monitoring team occurs during pile-driving to modify zones of influence related to noise thresholds for marine mammals, if needed and approved by NMFS.

1.1 Summary of Applicable Noise Thresholds

In July 2016, NMFS issued technical guidance related to the level of impact expected from exposure of marine mammals to anthropogenic sounds in the water (presented in Table 1). For Level A harassment due to cumulative noise exposure, pinnipeds were divided into two groups: phocids (true seals) and otariids (eared seals) and cetaceans were separated into three groups based on their predominant sensitivity to lower, mid-level, or higher frequencies. For Level B harassment, thresholds are established for continuous (i.e., vibratory driving) and impulsive (i.e., impact driving) sounds, and not divided by hearing groups (Table 1). In 2018, a Technical Guidance update was adopted that confirmed that the best available science was used to develop the thresholds included in the 2016 guidance and that they were appropriate.

Table 1
Injury and Behavioral Disruption Thresholds for Airborne and Underwater Noise

Hearing Group and Species Considered in this IHA	Airborne Threshold (Impact and Vibratory Pile-Driving)	Underwater Continuous Noise Thresholds (e.g., Vibratory Pile-Driving)		Underwater Impulse Noise Thresholds (e.g., Impact Pile-Driving)		
	Level B RMS Threshold[1]	Level A cSEL Threshold	Level B RMS Threshold	Level A Peak Threshold[2]	Level A cSEL Threshold[2]	Level B RMS Threshold
Phocids (Pacific harbor seal and northern elephant seal)	90 dB (unweighted)	201 dB	120 dB	218 dB	185 dB	160 dB
Otariids (California sea lion and Stellar sea lion)	100 dB (unweighted)	219 dB	120 dB	232 dB	203 dB	160 dB
Low-Frequency Cetaceans (gray whale)	N/A	199 dB	120 dB	219 dB	183 dB	160 dB
Mid-Frequency Cetaceans (killer whale)	N/A	198 dB	120 dB	230 dB	185 dB	160 dB
High-Frequency Cetaceans (harbor porpoise)	N/A	173 dB	120 dB	202 dB	155 dB	160 dB

Notes:

1 The airborne disturbance guideline applies to hauled-out pinnipeds.

2 Level A threshold for impulse noise is a duel criterion based on peak pressure and cSEL. Thresholds are based on the NMFS 2016 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing.

Underwater peak and RMS are referenced (re): 1 µPa; cSEL is re: 1 μPa^2-sec; Airborne RMS is re: 20 µPa.

dB = decibel
IHA = Incidental Harassment Authorization
N/A = Not applicable, no thresholds exist
NMFS = National Marine Fisheries Service
µPa = micropascal
RMS = root mean square
sec = second
cSEL = cumulative sound exposure level

2.0 OVERVIEW OF PROJECT ACTIVITIES AND PROJECT LOCATION

Jordan Cove Energy Project L.P. (JCEP) is proposing to construct a liquefied natural gas (LNG) production facility in Coos Bay, Oregon (LNG Terminal). Natural gas will be delivered via pipeline to the facility, liquefied on site, and loaded on LNG carriers for export (Figure 1). The Project includes construction at the LNG Terminal and related activities (or Ancillary Activities) and construction of the Pipeline. Only certain pile driving activities at the LNG Terminal – Marine facilities and Ancillary Activities as described below will result in noises in the marine environment that could affect marine mammals. The LNG Terminal would be constructed over a period of three years and includes the following elements:

- **LNG Terminal - Land-based components** of the LNG terminal consist of a gas conditioning plant, a utility corridor, liquefaction facilities (including five liquefaction trains) and two full-containment LNG storage tanks. These land-based components are far enough removed from the Bay shoreline that noise is not expected to be generated into the water and so these activities will not be monitored per this plan;

- **LNG Terminal - Marine facilities** include LNG loading facilities, a marine slip, a Material Offloading Facility (MOF), including a Temporary Materials Barge Berth (TMBB), and an access channel between the federal navigation channel and the LNG loading dock in the slip. The Marine facilities activities that will be performed in the first year of construction that could generate sounds that could exceed the NMFS thresholds include sheet pile-driving at the MOF, sheet pile-driving of in the southwest corner of the marine slip, and pile-driving at the TMBB (Figure 2).

- **Ancillary Activities** include work at the Navigation Reliability Improvements (NRI) dredge areas 1 through 4, the TransPacific Parkway/US-101 (TPP/US-101) Intersection Widening, APCO sites 1 and 2, Kentuck Project site, and Eelgrass Mitigation site. Pile-driving and extraction activities that could generate noise that could exceed the NMFS thresholds include temporary piles associated with barge access at the dredging sites as well as pile driving for construction at the TPP/US-101 and APCO sites (Figure 2).

The activities that would occur in Year 1 and are the subject of this plan are further described below.

2.1 Activities that May Result in Take – Year 1 Construction Season

Construction of the LNG Terminal and Ancillary Activities require in-water and "in-the-dry" pile-driving[1]. Piles that will be driven "in the dry" (as addressed in this plan) are piles that are driven into dry land sufficiently near the water's edge that noise may be generated indirectly into the water (within approximately 30 meters of the water's edge). Pile-driving would include impact and vibratory pile-driving. Underwater sound and acoustic pressure resulting from pile-driving activities could affect marine mammals by causing behavioral avoidance of the construction area (Level B harassment). No construction activities are anticipated to result in lethal take or serious injury of marine mammals.

Table 2 presents the Year 1 construction activities that have potential for either Level A or Level B harassment of marine mammals. Additional details about each activity is included in the IHA Application.

[1] Pile-driving includes both pipe piles and sheet piles.

Table 2
Activities with the Potential to Harass Marine Mammals, Year 1 Construction Season

Location	Driving Method	In water/ In-the-Dry	Quantity	Pile Type
LNG Terminal				
Sheet Piles at MOF	Vibratory	In-the-dry	1,869	Sheet Pile
Sheet Piles at South West Berth Wall (within 30-meter setback from Bay)	Vibratory	In-the-dry	113	Sheet Pile
TMBB mooring piles	Vibratory	In-the-dry	6	24-inch Pipe Pile
Ancillary Activities				
TPP/US-101 intersection (roadway grid support)	Vibratory/Impact	In partially dewatered cofferdam	1,150	14-inch Timber Pile
TPP/US-101 intersection (cofferdam)	Vibratory	In water	311	Sheet Pile
TPP/US-101 intersection (work access bridge)	Vibratory/Impact	In water	36	24-inch Pipe Pile
APCO sites (including temporary bridge, receiving barge mooring, dredge offloading area and cradle support)	Vibratory	In water	33	24-inch Pipe Pile

Notes:
MOF = Material Offloading Facility
TMBB = Temporary Materials Barge Berth
TPP = TransPacific Parkway

The estimated distances from pile-driving where marine mammals could be impacted are shown in Tables 3 and 4. Additional details can be found in Section 5 of the IHA Application. Due to the conservative nature of the calculations used to estimate the Level A and Level B zones, JCEP anticipates that the actual areas of Level A and Level B harassment are smaller than what are presented in Tables 3 and 4. Hydroacoustic monitoring would be implemented to confirm, and if warranted, revise zones during construction activities, with NMFS approval.

For marine mammal species identified in section 2.1, the areas where Level A thresholds could be exceeded are considered work shutdown zones in order to ensure that Level A take does not occur. If the Level A zone is smaller than 10 meters, a minimum shutdown zone of 10 meters from pile driving activities listed in Table 2 will be implemented as a protective measure. No pile-driving activities will occur if a marine mammal is observed in the respective shutdown zone for that species.

If the MMOs become aware that species for which no take has been authorized are within Coos Bay, including listed whale species, the animal's position will be monitored and a work shutdown would occur if the animal(s) have potential to enter a Level B harassment zone.

Table 3
Estimated Pile-Driving Noise Levels and Distances of Level A Threshold Exceedance with Impact and Vibratory Driver

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level A Threshold[1], in meters[2]				
	Peak[3]	RMS (vibratory)/ SEL (impact)	Phocids	Otariids	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans

LNG Terminal							
Sheet Piles at MOF/South West Berth wall and 24-inch TMBB Mooring Piles – Vibratory in-the-dry	--[4]	--[4]	NE	NE	NE	NE	NE
Ancillary Activities							
24-inch Pipe Piles at TPP/US-101 – Impact with BCA	201	166 SEL	34	2	63	2	75
14-inch Timber Piles at TPP/US-101– Impact within cofferdam	180	160 SEL	25	2	46	2	55
24-inch Pipe Piles at, TPP/US-101 and APCO sites – Vibratory in-water	191	165 RMS	9	1	15	1	23
14-inch Timber Piles at TPP/US-101 – Vibratory within cofferdam	172	162 RMS	7	<1	11	1	17
Sheet Piles at TPP/US-101 – Vibratory in-water	175	160 RMS	5	<1	8	1	12

Notes:

1 Level A thresholds are based on the NMFS 2016 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing; cSEL threshold distances are shown. See footnote 3 below.

2 Where noise will not be blocked by land masses or other solid structures. Values in feet have been converted from fractional meters values, which may affect rounding during unit conversion.

3 All distances to the peak Level A thresholds are less than 10 meters.

4 Since these piles will be driven on land, source values at 10m are not available; distances are calculated by JASCO modeling

Distances are rounded to the nearest meter or are depicted as “<1.0” for values less than 1 meter.

BCA will be used during impact-driving of steel piles.

Peak, RMS and SEL are re: 1 µPa

µPa = microPascal
BCA = Bubble curtain attenuation will be used during impact driving of steel piles in water
dB = decibels
MOF = Material Offloading Facility
NMFS = National Marine Fisheries Service
NE = Not Exceeded
RMS = root mean square
TPP = TransPacific Parkway
SEL = Sound Exposure Limit

Table 4
Estimated Pile-Driving Noise Levels and Distances of Level B Threshold Exceedance with Impact and Vibratory Driver

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level B Threshold, in meters[1]
	Peak	RMS	160/120 dB RMS[2]
Marine Facilities			
Sheet Piles at MOF/West Berth wall and 24-inch TMBB Mooring Piles – Vibratory in-the-dry	--[4]	--[4]	1,914
Ancillary Activities			
24-inch Pipe Piles at TPP/US-101 Impact with BCA	201	177	136
14-inch Timber Piles at TPP/US-101– Impact within cofferdam	180	170	46
24-inch Pipe Piles at TPP/US-101, and APCO sites – Vibratory in-water	191	165	10,000
14-inch Timber Piles at TPP/US-101 – Vibratory within cofferdam	172	162	6,310
Sheet Piles at TPP/US-101 – Vibratory in-water	175	160	4,642

Notes:

1 Where noise will not be blocked by land masses or other solid structures.
2 For underwater noise, the Level B harassment (disturbance) threshold is 160 dB for impulsive noise (i.e. impact driving) and 120 dB for continuous noise (i.e. vibratory driving).

4 Since these piles will be driven on land, source values at 10 meters are not available; distances are calculated by JASCO modeling

Peak and RMS are re: 1 µPa.

BCA = Bubble curtain attenuation will be used during impact driving of steel piles in water.
µPa = microPascal
dB = decibels
TPP = TransPacific Parkway
MOF = Material Offloading Facility
RMS = root mean square

2.2 Species that Could Be Affected

As described in detail in Section 3 of the IHA application, the following species of marine mammals have potential to experience Level B Harassment as a result of pile-driving associated with Project construction activities:

- Pacific harbor seal (*Phoca vitulina*);
- Northern elephant seal (*Mirounga angustirostris,* California Breeding Stock);
- California sea lion (*Zalophus californianus*);
- Steller sea lion (*Eumetopias jubatus*, Eastern Distinct Population Segment [DPS]);
- Gray whale (*Eschrichtius robustus,* Eastern North Pacific DPS);
- Killer whale (*Orcinus orca*–transient population); and
- Harbor porpoise (*Phocoena phocoena*).

For the Year 1 construction season, no Level A take have been authorized. No species that take is being requested for is listed as endangered or threatened under the Endangered Species Act.

3.0 MARINE MAMMAL MONITORING

The marine mammal monitoring program will consist of one-time pre-construction surveys, visual monitoring during pile driving activities (i.e. construction monitoring), and post-construction reporting. NMFS-approved marine mammal observers (MMO) will be present for those construction activities that have potential to result in take of marine mammals (Table 2), including vibratory- and impact-driving activities. The number of MMOs present for each activity will be based on the type of activity being monitored, the monitoring location(s) available (shore-based or boat-based), and the size of the zones to be monitored. In general, at least two MMOs will be present for Ancillary Activities, and three MMOs will be present for the LNG Terminal - Marine Facilities activities. Monitoring locations will be specific to each activity and may be subject to change depending on physical conditions at the site. Monitors will be positioned on either land-based structures, the shoreline, or boats, depending on activity, best vantage point, and field and safety conditions.

3.1 Pre-Construction Monitoring

A two-person MMO team will complete a one-time, boat-based, 2-day pre-construction survey of potential Level B harassment zones prior to pile driving activities at the LNG Terminal Marine Facilities (Table 2). A 1-day survey would be conducted at the TPP/US-101 and APCO sites prior to pile driving work The surveys will include on-water observations at each of the pile driving locations to observe species numbers and general behaviors of animals in the area. Surveys will occur no earlier than 7 days before the first day of construction at each activity site.

Special attention will be given to the two closest harbor seal haul-out sites in proximity to the project area—Clam Island and Pigeon Point—as described in Section 4 of the IHA application. On each of the monitoring days, monitoring will occur for up to 12 hours (weather-dependent), to include one low-tide survey and one high-tide survey in daylight hours. A small boat will be used for the survey from various locations that provide the best vantage points. The information collected from monitoring will be used for comparison with results of marine mammal behaviors during pile-driving activities and will contribute to baseline monitoring data for the area.

3.2 Construction Monitoring

For some marine mammal hearing groups, the Level A thresholds would only be expected to be exceeded within a few meters of pile-driving; in other cases, the Level A thresholds could be exceeded out to 75 meters (Table 3). A shutdown zone equal to or larger than the Level A zone is established for each activity, and a minimum shutdown zone of 10 meters have conservatively been established for all pile-driving.

The MMO(s) will observe the shutdown zones from the most practicable vantage points possible. It is anticipated that MMOs will be situated on land primarily and have one boat based location for the larger Level B zones related to pile driving at the MOF and TMBB. The locations are subject to change in the field based on construction activities, safety zones, and weather conditions. Proposed monitoring locations are shown in Figures 3 through 8.

Generally speaking, the MMOs may be able to observe larger cetaceans, such as gray whales or killer whales, which are within 2,000 meters of pile driving, and smaller marine mammals within 500 to 1,000 meters, depending on weather conditions. Recording all marine mammal activity in the entirety of the vibratory driving Level B harassment zones is not practicable and is not anticipated. The Level B harassment zone will be monitored out to approximately 2,000 meters and then using the daily density calculated for each species observed, the number of Level B take will be extrapolated out to the full zone or if hydroacoustics data is available, the measured Level B zone.

The following is a summary of the shutdown zones and harassment zones (i.e. monitoring zones) for the LNG Terminal and the Ancillary Activities (Table 5 and 6, respectively, Figures 3 through 8), based on distances to the Level A and Level B thresholds, but rounded up to a whole number for ease of field-verifying.

The shutdown zones and surrounding areas will be monitored for 30 minutes prior to any pile driving activities to ensure that the area is clear of any observable marine mammals. If marine mammals are sighted in the shutdown zone (for example, in the case of harbor seal during vibratory driving, a 10-meter shutdown zone), the start of pile driving activities will be delayed to allow the animals to move out of the area. If a marine mammal is seen above water in the shutdown zone and then dives below, the contractor will wait 15 minutes for pinnipeds (harbor seal, California sea lion, northern elephant seal and Stellar sea lion) and small cetaceans (harbor porpoise), and 30 minutes for gray whales and killer whales. If no marine mammals are observed in the shutdown zone in that time, it will be assumed that the animal has moved beyond the shutdown zone and pile driving can be initiated.

Table 5
Year 1 Construction Season Level B Harassment and Shutdown Zones for LNG Terminal in Meters[1]

Species	Vibratory Pile-Driving Sheet Piles at MOF/West Berth wall and TMBB Mooring Piles[2]
Level B Harassment Zone	
All Species with Take Authorized	1,920
Shutdown Zone[3]	
Pacific Harbor Seal	10 (<10)
Northern Elephant Seal	10
California Sea Lion	10
Stellar Sea Lion	10
Gray Whale	10
Killer Whale	10
Harbor Porpoise	10

Notes:

[1] Shutdown Zone is applicable for all pile-driving and extraction activities for all marine mammal species groups. Exact distances for each hearing group for each activity type are all within 10 meters.

[2] Some exact values have been rounded up for purposes of ease in monitoring.
[3] The shutdown zone is larger than the Level A zone for all other species.

TMBB = Temporary Material Barge Berth
MOF = Material Offloading Facility

Table 6
Year 1 Construction Season Level B Harassment and Shutdown Zones for Ancillary Activities in meters[1]

Species	Impact Pile Driving		Vibratory Pile-Driving	
	Timber Piles at TPP/US-101	Pipe Piles at TPP/US-101	Pipe Piles, Timber Piles and Sheet Piles at TPP/US-101	Pipe Piles at APCO
Level B Harassment Zone				
All Species with Take Authorized	50	350	7,000[2]	7,000[2]
Shutdown Zone [3]				
Pacific Harbor Seal	30	70	10	10
Northern Elephant Seal	30	70	10	10
California Sea Lion	10	10	10	10
Stellar Sea Lion	10	10	10	10
Gray Whale	60	140	25	30
Killer Whale	10	10	10	10
Harbor Porpoise	60	140	25	30

Notes:

1 Shutdown Zone is applicable for all pile-driving and extraction activities for all marine mammal species groups. Exact distances for each hearing group for each activity type are all within 10 meters.

2 Level B monitoring zone is limited by the distance to the shorelines within the bay and feasible line of site for a MMO. For example, the shoreline at the TPP/US-101 location limits the extent of the Level B zone to 1,500 meters or less. For purposes of counting take, observations made within 2000 meters will be used to determine an animal density for the day and then take will be extrapolated out to the full Level B zone.

3 For species where the shutdown zone, as determined by using the Level A cumulative SEL threshold, is larger than the Level B harassment zone, Level B take would not occur.

TPP = TransPacific Parkway

Once pile driving has been initiated, monitoring of the applicable shutdown zone and visible portions of the Level B zone will continue. If a marine mammal enters a shutdown zone during active pile driving the MMO will signal to the pile driving crew to immediately stop work. Once the animal has been observed leaving the shutdown zone, pile driving may resume. If a marine mammal is seen above water in the shutdown zone and then dives below, the contractor will wait 15 minutes for pinnipeds (harbor seal, California sea lion, northern elephant seal and Stellar sea lion) and small cetaceans (harbor porpoise), and 30 minutes for gray whales and killer whales. If no marine mammals are observed in the shutdown zone in that time, it will be assumed that the animal has moved beyond the shutdown zone and work can resume.

If a marine mammal is observed in the applicable Level B zone during active pile driving (Tables 5 and 6), but is outside of the respective shutdown zone during pile driving, the activity will continue and the behavior of the animal will be monitored and documented. If the animal appears distressed by the pile driving activity, work may be stopped at the MMO's discretion, in conjunction with the construction manager, until the animal leaves the Level B zone. MMO observations will be made using binoculars from boats or accessible locations along the waterfront to provide sufficient coverage of the shutdown zones. Proposed monitoring locations are shown in Figures 3 through 8, these locations are subject to change in the field based on construction activities, safety zones, and weather conditions.

3.3 Post-Construction Monitoring

The MMO will continue to observe the shutdown zone and surrounding areas for a minimum of 30 minutes after pile-driving stops, and record observations of marine mammals and their behaviors.

4.0 QUALIFICATIONS AND RESPONSIBILITIES FOR MMOS

4.1 Minimum Qualifications for MMOs

To be considered qualified to record observations of marine mammals under this Plan, observers must meet the following criteria:

- Visual acuity in both eyes (correction is permissible) sufficient for discernment of moving targets at the water's surface, with the ability to estimate target size and distance; use of binoculars may be necessary to identify marine mammals;
- Experience in conducting field observations and collecting data according to assigned protocols (this may include academic experience), and ability to perform these tasks;
- Experience or training in the identification of marine mammal species and behaviors;
- Sufficient training, orientation, or experience working from boats (if applicable) and with the construction operation to provide for personal safety during observations;
- Writing skills sufficient to prepare a report of marine mammal observations, including marine mammal species observed in the shutdown and behavioral disturbance zones; and
- Ability to communicate with Project personnel orally, by radio, and in person to provide real-time information on marine mammals observed in the area, as necessary.

All MMOs l will be provided a copy of this monitoring plan and the IHA. Monitoring personnel must read and understand the contents of this plan—as well as the IHA—as they relate to coordination, communication, and identification and reporting of incidental harassment of marine mammals.

4.2 MMO Responsibilities

MMO tasks associated with monitoring and reporting requirements for each of the activities covered under this Plan are summarized below:

- Verifying shutdown zone distances from the pile to be extracted/installed, in coordination with the acoustic monitors;
  - Monitoring the shutdown zone and surrounding areas 30 minutes before pile-driving is initiated to ensure that marine mammals are not present;
  - Monitoring for the entirety of the pile-driving event;
  - Monitoring the shutdown zone and surrounding areas for a minimum of 30 minutes after pile-driving stops;
  - Recording instances of potential Level B harassment, as authorized for all marine mammals covered by the IHA;
  - Signaling shutdowns, as needed, if unauthorized take is about to occur;
  - Recording shutdown events and the behavior of the animal that initiated the shutdown event;
  - Monitoring and documenting behaviors of any marine mammal activity in the vicinity of the pile-driving activity, as described in Section 3.0;
  - Coordinating with JCEP, construction contractor(s), and other monitors on site;
  - Preparing Monitoring Data Sheets; and
  - Preparing a post-construction report.

5.0 DATA COLLECTION AND REPORTING

5.1 Monitoring Data

Observations will be recorded, and will include the following, to the extent available:

- Environmental conditions (e.g., weather, sea state, tides, etc.);
- Species;
- Sex and age class;
- Number of animals;
- Description of behavior, including the location and direction of movement;
- Time of observation;
- Construction activity, including the time that pile-driving begins and ends; and
- Other non-project acoustic or visual disturbances that may be influencing behavior.

The reactions of marine mammals will be recorded based on the following classifications: 1) no response; 2) head alert (e.g., looks towards the source of disturbance); 3) approaches in water (but does not leave); and 4) retreat or flush (e.g., leaves the area or flushes from the haul-out site). Sample field forms are included in Attachment A.

If a marine mammal carcass is found in the area, the event would be reported to NMFS according to the following schedule:

1. If a carcass is found and it is determined that it was caused by the activities covered by the IHA, the contractor will immediately cease all activities and NMFS will be notified immediately. The MMO will gather required data and report to NMFS.

2. If a carcass is found and the cause is unknown, NMFS will be notified immediately, and the MMO will report the required data. Activities could continue while NMFS reviews the incident.

3. If a carcass is found and the cause is determined to not be associated with the activities covered by the IHA, the MMO will report it to NMFS within 24 hours, with the required data. Construction activities would not be interrupted.

If accessible to the MMO, the carcass would be geo-tagged; and if possible, the MMO would determine and record the species, age, and sex for reporting to NMFS.

5.2 Monitoring Equipment

The following equipment will be used by the MMOs:

- A rangefinder capable of achieving an accuracy of ± 5 feet at a range of 100 feet;
- Binoculars;
- Radio or cell phone; and
- Monitoring Data Sheets.

The MMOs will use high-quality binoculars to monitor marine mammals at distant locations. A radio or cell phone will be used to coordinate with the construction contractor, the acoustics team, and other MMOs. To the extent practicable, digital video or 35-millimeter still cameras will be used to document the behavior and response of marine mammals to construction activities or other disturbances.

5.3 Reporting

The following sections detail the NMFS reporting requirements pursuant to the IHA.

5.3.1 Monitoring Data Sheets

Monitoring Data Sheets that summarize the monitoring results, construction activities, and environmental conditions will be compiled and submitted with the post-construction monitoring report (Attachment A).

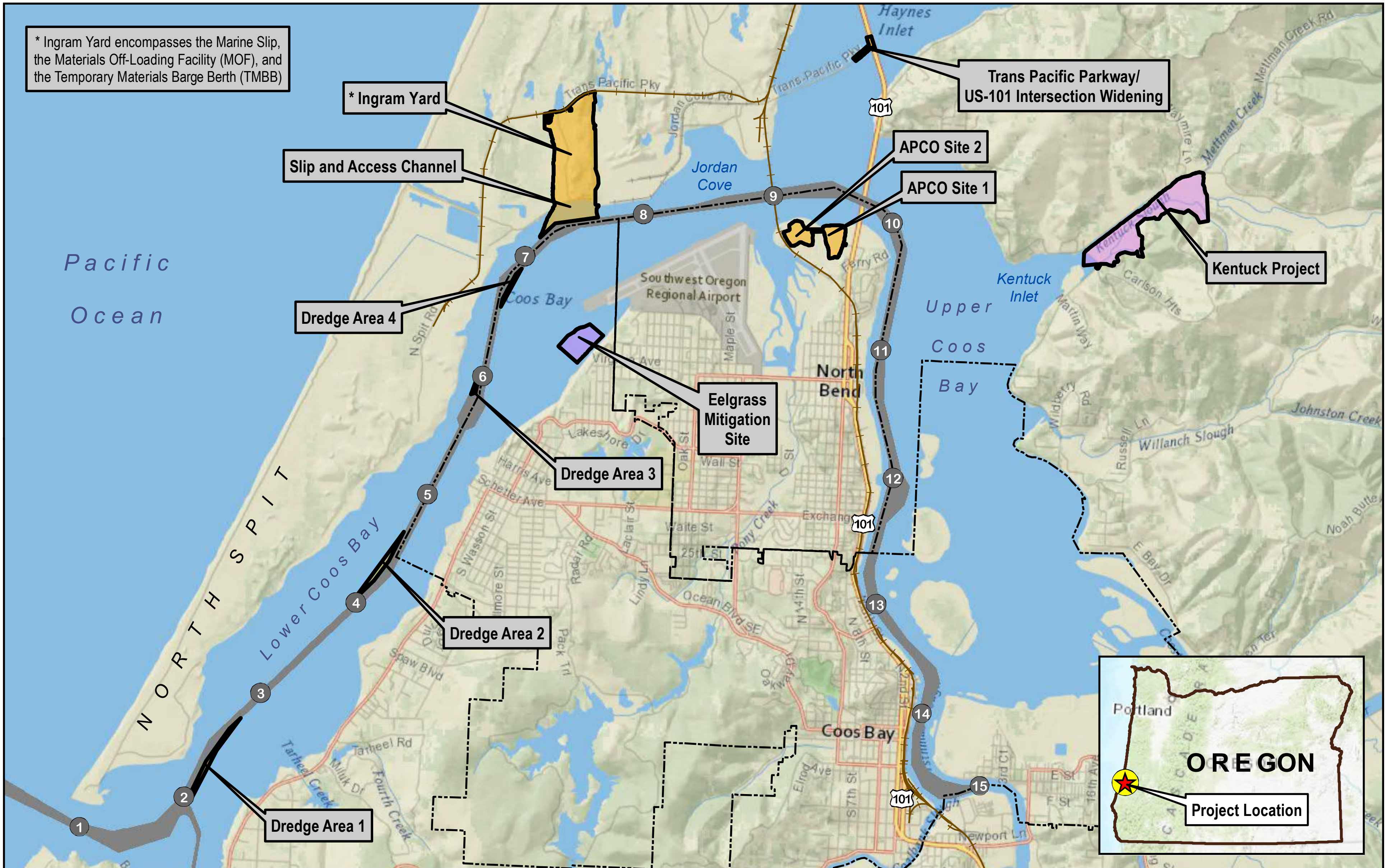
5.3.2 Post-Construction Monitoring Report

A draft report will be submitted to NMFS within 90 days after completion of the pile driving activities that take place in the first year or as required in the IHA. The draft report will include a description of the materials and methods used in monitoring; an overall summary of the monitoring results; a summary of Level B harassment for all authorized species; a discussion of the compliance record over the course of the entire program; and a discussion of the effectiveness of monitoring methods.

A final report will be prepared and submitted to NMFS within 30 days following receipt of any comments on the draft report.

The marine mammal monitoring reports will provide useful information that would allow design of future projects to reduce incidental take of marine mammals. JCEP would share field data and behavioral observations on marine mammals that occur in the Project area. This information could be made available to federal, state, and local resource agencies, scientists, and other interested parties on written request.

Figures



JCEP Project Area*

Federal Navigation Channel

Mitigation Site

River Mile

N

0 1 Mile

* Only a portion of the JCEP Project Area is shown

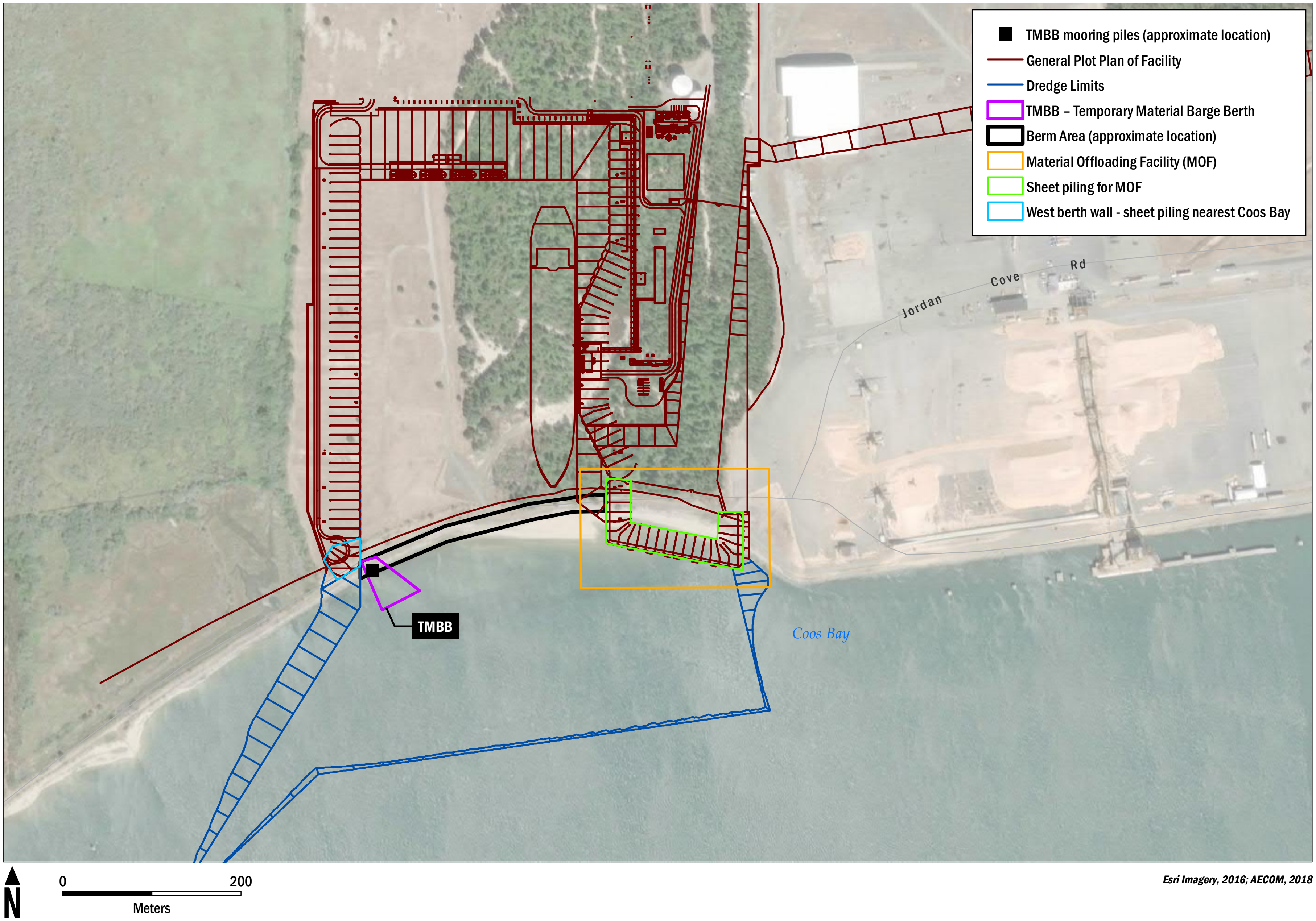
Jordan Cove Energy Project, L.P.

Jordan Cove Energy Project

Figure 1

Project Location Map

AECOM Oakland CA 7/12/2019 USER arakis PATH L:\Projects\GIS\Projects\JordanCove_LNG\02_Maps\02_Map_Production_and_Reports\IHA\Fig1_4_Marine_Facility_Pile_Plan_Year1.mxd



Esri Imagery, 2016; AECOM, 2018

AECOM

Jordan Cove LNG

LNG Terminal in Coos Bay, OR

FIGURE 2

Marine Facilities Pile Plan

Year 1

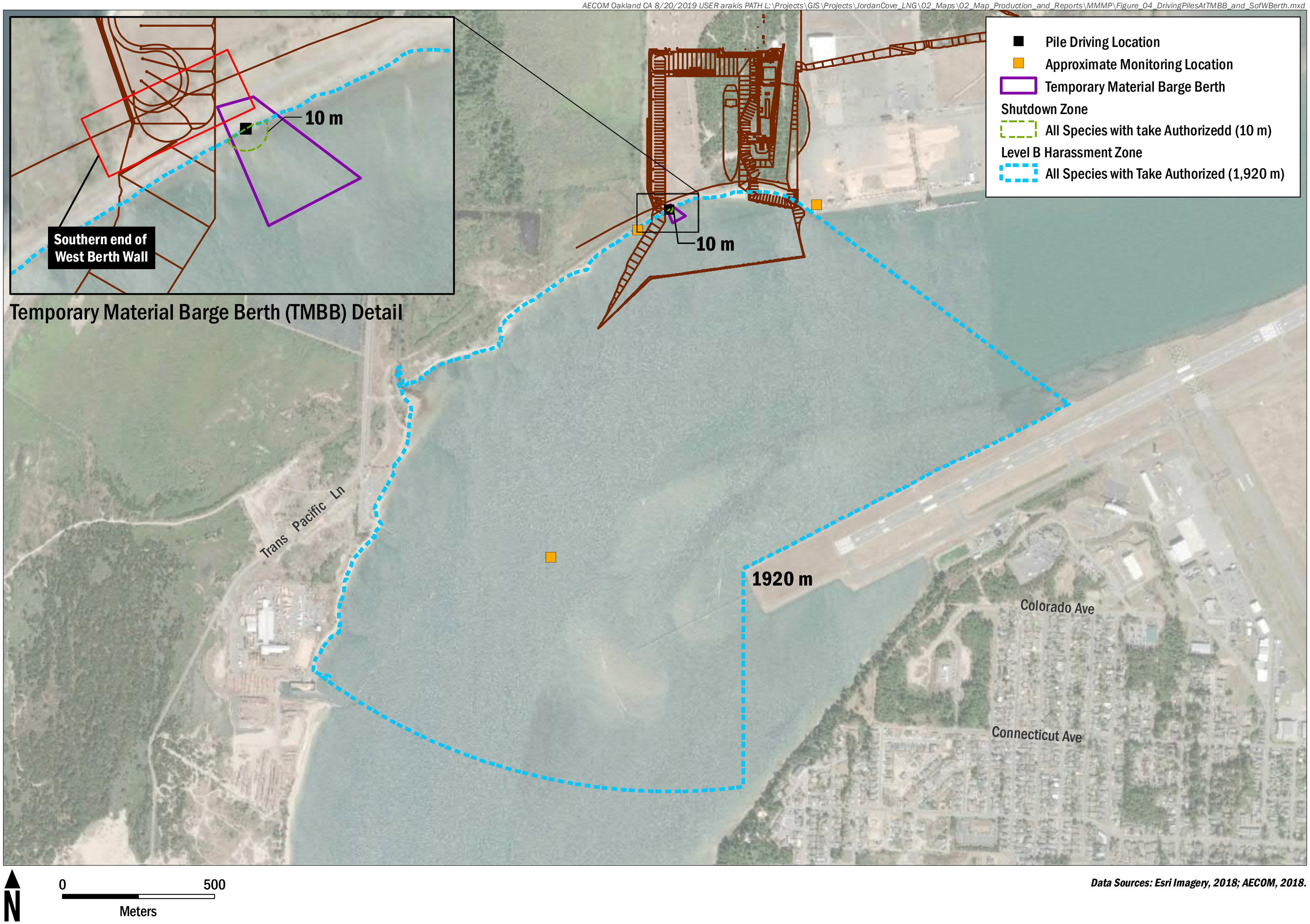
Data Sources: Esri Imagery, 2018; AECOM, 2018.

AECOM
Jordan Cove LNG
LNG Terminal in Coos Bay, OR

FIGURE 3

Marine Mammal Monitoring Zones for Vibratory Driving of Sheet Piles at MOF Face

AECOM Oakland CA 8/20/2019 USER arakis PATH L:\Projects\GIS\Projects\JordanCove_LNG\02_Maps\02_Map_Production_and_Reports\MMMP\Figure_04_DrivingPilesAtTMBB_and_SofWBerth.mxd



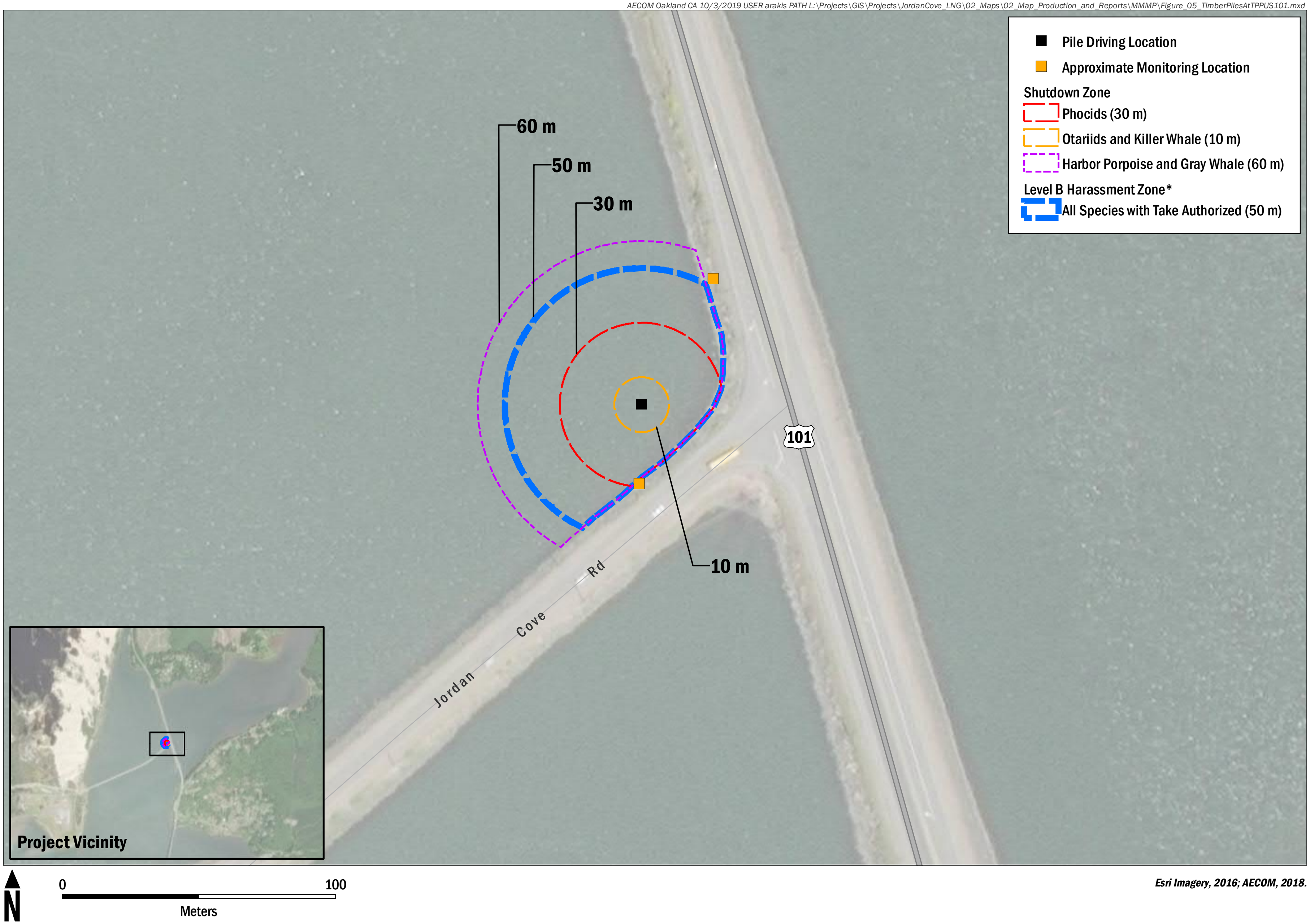
Data Sources: Esri Imagery, 2018; AECOM, 2018.

AECOM
Jordan Cove LNG
LNG Terminal in Coos Bay, OR

FIGURE 4

Marine Mammal Monitoring Zones for Vibratory Driving Piles at TMBB and Southern End of West Berth Wall

AECOM Oakland CA 10/3/2019 USER arakis PATH L:\Projects\GIS\Projects\JordanCove_LNG\02_Maps\02_Map_Production_and_Reports\MMMP\Figure_05_TimberPilesAtTPPUS101.mxd



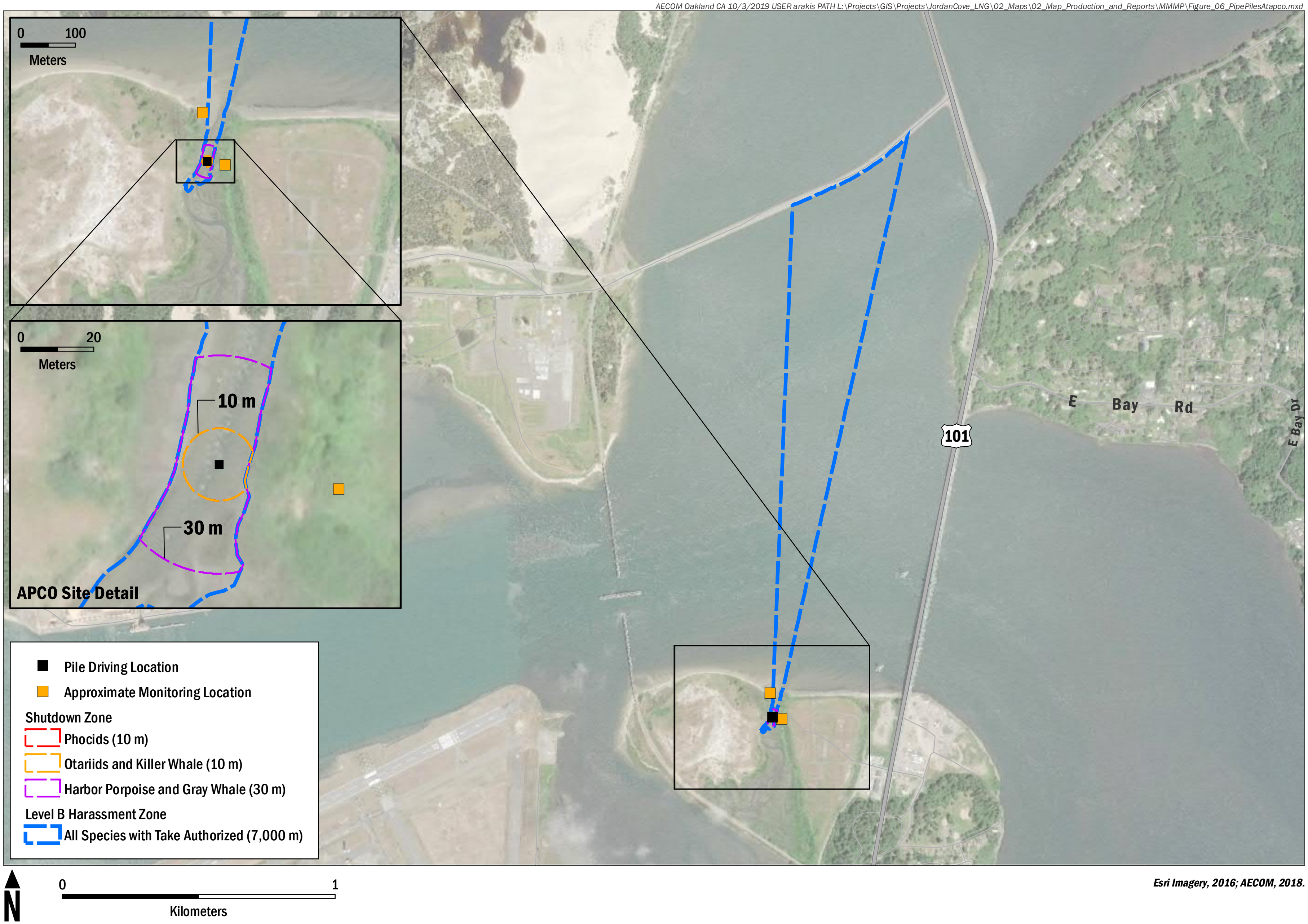
Esri Imagery, 2016; AECOM, 2018.

AECOM
Jordan Cove LNG
LNG Terminal in Coos Bay, OR

* For species where the shutdown zone, as determined using the Level A cumulative noise thresholds, is larger than the Level B zone, Level B take would not occur.

FIGURE 5

Marine Mammal Monitoring Zones for Impact Driving of Timber Piles at TPP/US-101



AECOM
Jordan Cove LNG
LNG Terminal in Coos Bay, OR

FIGURE 6

Marine Mammal Monitoring Zones for Vibratory Driving of Pipe Piles at APCO Site

AECOM Oakland CA 10/3/2019 USER arakis PATH L:\Projects\GIS\Projects\JordanCove_LNG\02_Maps\02_Map_Production_and_Reports\MMMP\Figure_07_DrivingPilesAtTPPUS101.mxd

Esri Imagery, 2016; AECOM, 2018.

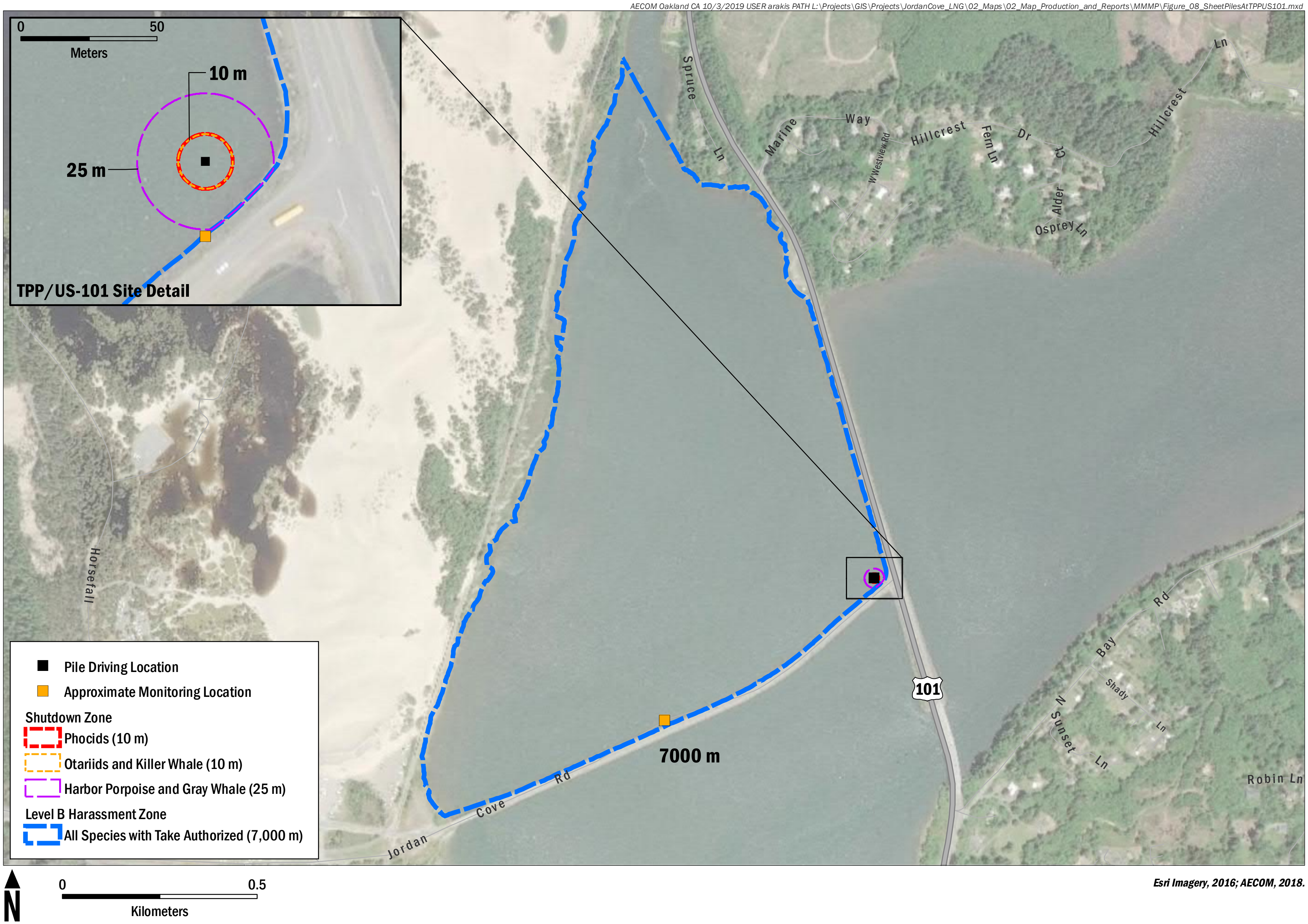
AECOM

Jordan Cove LNG

LNG Terminal in Coos Bay, OR

FIGURE 7

Marine Mammal Monitoring Zones for Impact Driving of Pipe Piles at TPP/US-101



Esri Imagery, 2016; AECOM, 2018.

AECOM
Jordan Cove LNG
LNG Terminal in Coos Bay, OR

FIGURE 8
Marine Mammal Monitoring Zones for Vibratory Driving of Pipe, Timber, and Sheet Piles at TPP/US-101 Site

Attachment A – Example Field Sheets

Date: _______________

Page ___ of ___

Daily Marine Mammal Monitoring Data Sheet 1
Jordan Cove Energy Project

MMO: ____

Other personnel onsite: ____

Time		Air Temp (°F)	Wave Height (ft.)	Wind (mph)	Cloud Cover (%)
Starting					
Ending					

Tidal Information* (Gauge: ______________________________________)		
Sunrise: ___________	Sunset: ___________	
High/Low	**Tide Time**	**Height (ft.)**

Other Notes:

Date: ________________

Page ___ of ___

Daily Marine Mammal Monitoring Data Sheet 2
Jordan Cove Energy Project

Comment Reference Number	Pile Number	Method of Pile-Driving (Impact/ Vibratory)	Pile-Driving Start/End Time	Observation Start/End Time	Mammal Species		
					Species[1]	Sex/ Age Class	Number

1 CL = California sea lion; PH = Pacific harbor seal; SL = Stellar sea lion; HP = harbor porpoise; GW = gray whale; KW = killer whale; O = Other (include name); ES = northern elephant seal

Date: ________________
Page ___ of ___

Daily Marine Mammal Monitoring Data Sheet 3
Jordan Cove Energy Project

Behavioral Observations

Comment Reference Number	Monitor's Distance from Project Activities	Behavior of Marine Mammal	Changes in Marine Mammal Behavior (i.e., orientation, speed, diving, etc.)

Appendix F: Hydroacoustic Monitoring Plan, Jordan Cove Energy Project

AECOM Imagine it. Delivered.

Jordan Cove Energy Project, L.P.

Hydroacoustic Monitoring Plan Jordan Cove Energy Project for Year 1 Construction

Docket No. CP17-495-000

September 2019

Prepared for:

Jordan Cove Energy Project, LP
5615 Kirby Drive, Suite 500
Houston, TX 77005

Prepared by:

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Table of Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

CDF	Cumulative Distribution Function
CM	Channel Mile
cSEL	cumulative sound exposure level
dB	decibel(s)
DPS	Distinct Population Segment
FERC	Federal Energy Regulatory Commission
FNC	Federal Navigation Channel
HUC	Hydrologic Unit Code
Hz	hertz
IHA	Incidental Harassment Authorization
JCEP	Jordan Cove Energy Project, LP
kHz	kilohertz
LNG	liquefied natural gas
LNG Terminal	LNG export terminal on the bay side of the North Spit of Coos Bay, Oregon
MLLW	mean lower low water
MOF	Material Offloading Facility
NAVD88	North American Vertical Datum of 1988
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NRI	Navigation Reliability Improvements
ODFW	Oregon Department of Fish and Wildlife
Plan	Hydroacoustic Monitoring Plan
RMS	root-mean-square
SEL	sound exposure level
.txt	text file
TMBB	Temporary Materials Barge Berth
TPP	TransPacific Parkway
uPa	microPascal
US-101	U.S. Highway 101
USGS	U.S. Geological Survey
.wav	wave file

1.0 INTRODUCTION

In September 2017, Jordan Cove Energy Project, LP (JCEP; the project) filed an application with the Federal Energy Regulatory Commission (FERC) under Section 3 of the Natural Gas Act, to construct and operate a liquefied natural gas (LNG) export terminal on the bay side of the North Spit of Coos Bay, Oregon (LNG Terminal). The LNG Terminal would be capable of receiving and loading ocean-going LNG carriers, to export LNG to Asian markets, and would be sized to export 7.8 million metric tons of LNG per annum.

This Hydroacoustic Monitoring Plan (Plan) has been developed in coordination with the National Marine Fisheries Service (NMFS) and is designed to verify that underwater noise thresholds for marine mammals are not exceeded over distances greater than predicted in the Incidental Harassment Authorization (IHA). A representative subset of each pile type and installation method would be monitored. The results of this hydroacoustic monitoring also may be used, in coordination with NMFS, to reduce monitoring zone radii during specific pile driving activities. The results also may be used to develop take estimates more accurately for subsequent years of construction. This plan is tailored for the pile driving activities that are scheduled to occur in the 2020–2021 construction season (Year 1) of project construction, as described in Sections 4 and 5.

The main components of the project would include:

- the LNG Terminal and associated facilities in Coos County, Oregon (Figure 1);
- construction activities related to the LNG Terminal construction but occurring at other locations in Coos County, hereafter referred to as Ancillary Activities (Figure 1); and
- the pipeline, which will cross portions of Klamath, Jackson, Douglas, and Coos counties in Oregon, and associated facilities.

Construction and operation of the pipeline would not generate noise levels that could exceed NMFS thresholds or otherwise harass marine mammals, and thus they are not discussed further in this Plan. The LNG Terminal would be constructed over approximately 3 years and include the following elements:

- **LNG Terminal land-based components** would consist of a gas conditioning plant, a utility corridor, liquefaction facilities (including five liquefaction trains), and two full-containment LNG storage tanks. These land-based components would be removed sufficiently from the Bay shoreline that noise is not expected to be generated into the water, and thus these activities would not be monitored, per the Plan; and
- **LNG Terminal marine facilities** would include LNG loading facilities, a marine slip, a Material Offloading Facility (MOF), including a Temporary Materials Barge Berth (TMBB) and an access channel between the federal navigation channel, and the LNG loading dock in the slip. The marine facilities activities to be performed in the first year of construction that could generate sounds that could exceed the NMFS underwater thresholds would include sheet pile-driving at the MOF, sheet pile-driving of in the southwestern corner of the marine slip, and pile-driving at the TMBB (Figure 2).

In addition to the LNG terminal, construction would occur in several other locations in Coos Bay for activities that are ancillary to the terminal itself, hereafter referred to as the Ancillary Activities. Ancillary Activities would be constructed over a 3 year period and include work at the Navigation Reliability Improvements (NRI) dredge areas 1 through 4, the TransPacific Parkway (TPP)/U.S. Highway 101 (US-101) Intersection Widening, APCO Sites 1 and 2, Kentuck Project site, and Eelgrass Mitigation site. In year one of construction, pile-driving activities associated with the ancillary activities that could generate noise that exceeds the NMFS thresholds would include temporary piles associated with barge access at the dredging sites as well as pile driving for construction at the TPP/US-101 and APCO sites.

Construction of the LNG Terminal and Ancillary Activities would require in-water and "in-the-dry" pile-driving. Piles driven "in the dry" (as addressed in this Plan) are piles that would be driven into dry land sufficiently near the water's edge that noise may be generated indirectly into the water. Pile-driving would include impact and vibratory pile-driving. Underwater sound and acoustic pressure resulting from pile-driving activities could affect marine mammals by causing behavioral avoidance of the construction area (Level B harassment) to seven species of marine mammals. No construction activities are anticipated to result in lethal take or serious injury of marine mammals. Additional details about each activity is included in the Application for Incidental Harassment Authorization for the Taking of Marine Mammals Under Section 101 (a)(5)(A) of the Marine Mammal Protection Act by the JCEP (IHA Application).

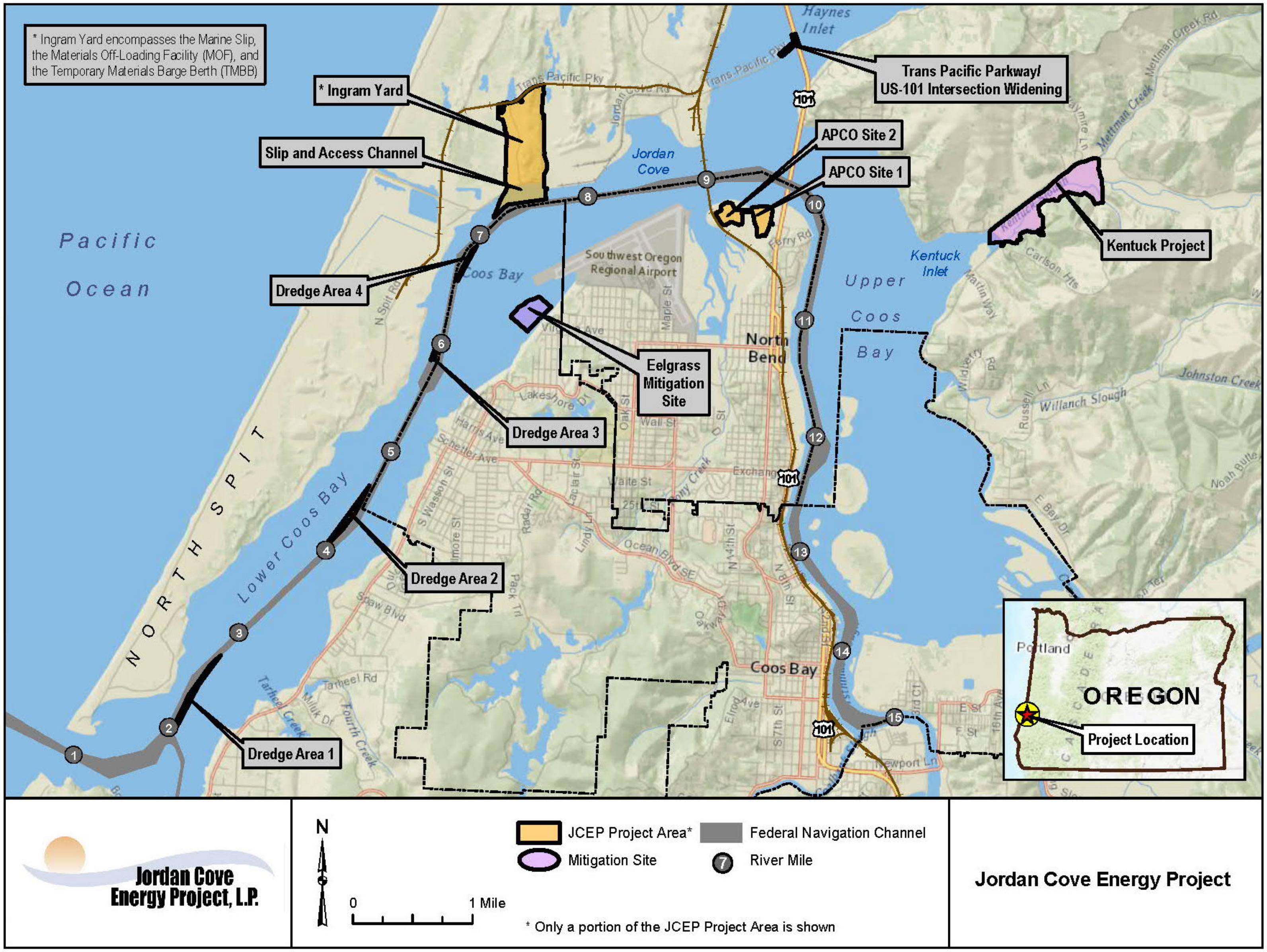

Figure 1. Site Location Map

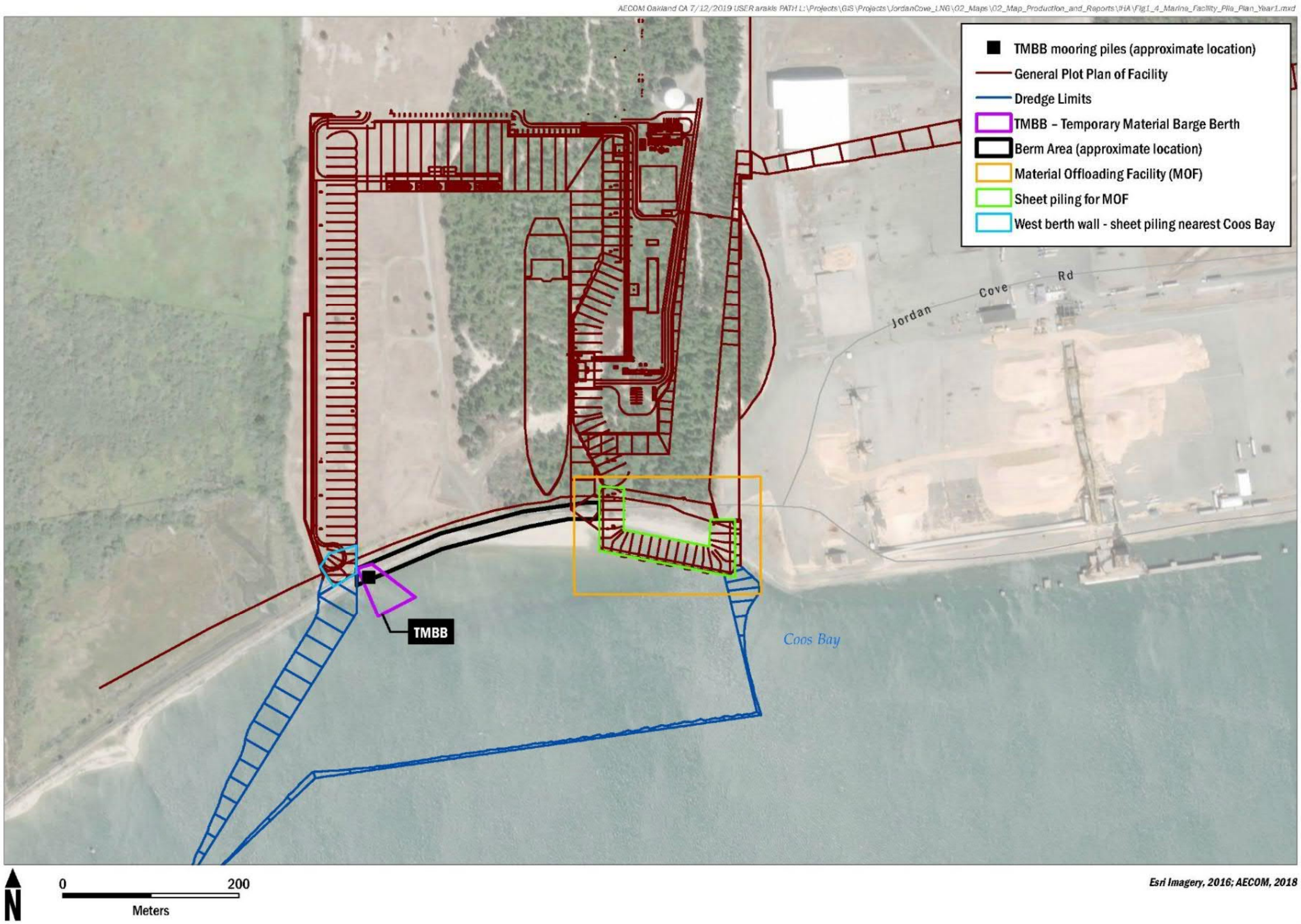

Figure 2. LNG Terminal Pile Plan – Year 1

2.0 PROJECT AREA

Coos Bay is an inland estuary, a semi-enclosed body of water that has tidal exchange with the Pacific Ocean. The surface area of Coos Bay covers about 50.1 square kilometers, measured at mean high water. The estuary is part of the U.S. Geological Survey (USGS)-designated watershed, Coos Bay (USGS Hydrologic Unit Code [HUC]:17100304). The watershed drains an area of approximately 1,914 square kilometers of Oregon's southern coastal range, within the larger South Coast Watershed Basin (ODEQ 2012). Coos Bay is fed by about 30 tributaries, including the Coos River, Millicoma River, Catching Slough, Isthmus Slough, Pony Slough, South Slough, North Slough, Kentuck Slough, and Haynes Inlet.

The marine environment along the transit route outside Coos Bay consists of varied habitats, used by aquatic organisms including commercial and recreationally important fish and shellfish, as well as by shorebirds, seabirds, and marine mammals. This habitat has gently sloping nearshore intertidal and subtidal sand areas near the Coos Bay mouth and rocky shorelines to the south. Sand and mud flats are the dominant intertidal and subtidal habitat type, but extensive eelgrass beds also are present. Eelgrass mapping surveys conducted between 2005 and 2014 detected more than 567 hectares of low and high-density eelgrass communities throughout upper and lower Coos Bay (Ellis Ecological Services 2007 and 2013). Resident and migrant shorebirds congregate on the tidally inundated mudflats along the shore of Coos Bay, to forage on the invertebrates in the shallow waters and exposed mudflats and eelgrass beds, especially during low tides.

Marine fish communities in Coos Bay consist of a diversity of estuarine and marine species. Their distribution and abundance vary with physical factors, such as bottom substrate, slope, current, salinity, and temperature, as well as season, which can affect life history components, such as migration and spawning timing.

The Coos Bay Federal Navigation Channel (FNC) is zoned Deep-Draft Navigation Channel (37-foot authorized draft). The FNC is bounded by the North Spit on the west and north, and the mainland to the south and east. Along the mainland bounding the FNC are the communities of Charleston and Barview, and the cities of Coos Bay and North Bend. The Coos Bay FNC extends from the mouth of Coos Bay to the city of Coos Bay docks, at about Channel Mile (CM) 15.1. The entrance to Coos Bay is between two jetties that are about 640 meters apart and extend about 915 meters from the shore. The channel width at the entrance mark is approximately 460 meters, reducing to approximately 210 meters at CM 0. From CM 1 to the LNG Terminal (at about CM 7.5), the authorized channel width is 91.4 meters. Channel depth is maintained at -11.3 meters mean lower low water (MLLW) for the length of the FNC. Outside the FNC, Coos Bay is relatively shallow, with an average depth of -4.3 meters MLLW (Partnership for Coastal Watersheds 2019). Roughly half of the Coos Bay estuary has a depth less than MLLW, and thus is intertidal (Partnership for Coastal Watersheds 2019). Figure 3 shows bathymetry in the areas surrounding the project area proposed for pile driving activities.

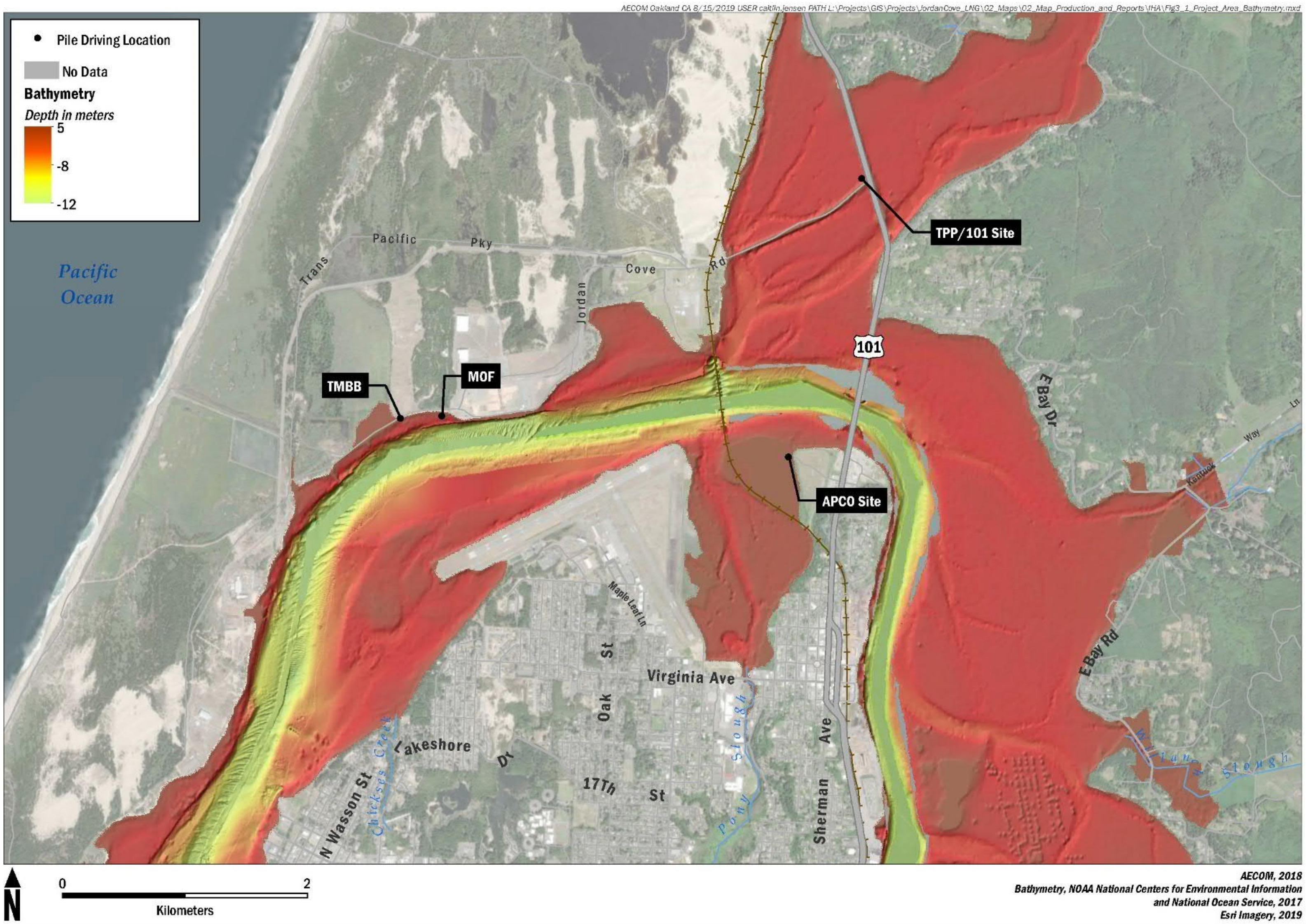

Figure 3. Project Area Bathymetry

3.0 PERMIT CONDITIONS

As described in detail in Section 3 of the IHA application, the following species of marine mammals have the potential to experience Level B Harassment from pile driving associated with project construction activities:

- Pacific harbor seal (*Phoca vitulina*)
- Northern elephant seal (*Mirounga angustirostris,* California Breeding Stock)
- California sea lion (*Zalophus californianus*)
- Steller sea lion (*Eumetopias jubatus,* Eastern Distinct Population Segment [DPS])
- Gray whale (*Eschrichtius robustus,* Eastern North Pacific DPS)
- Killer whale (*Orcinus orca*–transient population)
- Harbor porpoise (*Phocoena phocoena*)

No species for which take is being requested is listed as endangered or threatened under the federal Endangered Species Act.

To ensure the least practicable impact on marine mammal species, JCEP has devised the construction sequence to minimize the impacts from construction of the LNG Terminal on marine mammals. The basic concept of this construction sequence would be to excavate the majority of the slip and construct the associated structures while maintaining a natural earthen berm barrier, to physically partition Coos Bay from the slip area and other LNG Terminal construction activities. This construction method would allow year-round work on the bulk of the slip, without the construction activities coming in contact with or causing potentially adverse impacts on marine mammals or other marine life that may be present in Coos Bay. Retaining the berm for the majority of construction would be the primary in-water direct and indirect avoidance and minimization measure for the LNG Terminal.

JCEP would minimize in-water sound production by implementing additional minimization measures, such as using vibratory drivers to fully install sheet piles, using vibratory methods to install pipe piles to the maximum extent practicable, and installing all in-water impact driven pipe piles (Ancillary Activities) or before finishing with an impact hammer during the Oregon Department of Fish and Wildlife (ODFW) regulated in-water work window (October 1 through February 15), which would avoid harbor seal spring pupping season. In addition, JCEP would implement a robust monitoring program to assess impacts and record authorized take during those construction activities that are anticipated to result in noise levels that could exceed the applicable marine mammal thresholds.

For a detailed analysis of the modeled distances over which underwater noise may exceed NMFS thresholds, see Section 5.3 of the IHA. The goal of this hydroacoustic monitoring plan is to verify that the actual distance over which harassment thresholds may be exceeded are equal to or smaller than the distances modeled in the IHA. Those modeled distances are provided in Table 1-1 and 1-2, below.

Table 1-1
Estimated Pile-Driving Noise Levels and Distances of Level A Threshold Exceedance with Impact and Vibratory Driver

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level A Threshold[1], in meters[2]				
	Peak[3]	RMS (vibratory)/ SEL (impact)	Phocids	Otariids	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans
LNG Terminal							
Sheet Piles at MOF/South West Berth wall and 24-inch TMBB Mooring Piles – Vibratory in-the-dry	--[4]	--[4]	NE	NE	NE	NE	NE
Ancillary Activities							
24-inch Pipe Piles at TPP/US-101 – Impact with BCA	201	166 SEL	34	2	63	2	75
14-inch Timber Piles at TPP/US-101– Impact within cofferdam	180	160 SEL	25	2	46	2	55
24-inch Pipe Piles at, TPP/US-101 and APCO sites – Vibratory in-water	191	165 RMS	9	1	15	1	23
14-inch Timber Piles at TPP/US-101 – Vibratory within cofferdam	172	162 RMS	7	<1	11	1	17
Sheet Piles at TPP/US-101 – Vibratory in-water	175	160 RMS	5	<1	8	1	12

Notes:

1 Level A thresholds are based on the NMFS 2016 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing; cSEL threshold distances are shown. See footnote 3 below.

2 Where noise will not be blocked by land masses or other solid structures. Values in feet have been converted from fractional meters values, which may affect rounding during unit conversion.

3 All distances to the peak Level A thresholds are less than 10 meters.

4 Since these piles will be driven on land, source values at 10m are not available; distances are calculated by JASCO modeling

Distances are rounded to the nearest meter or are depicted as "<1.0" for values less than 1 meter.

BCA will be used during impact-driving of steel piles.

Peak, RMS and SEL are re: 1 µPa

µPa = microPascal
BCA = Bubble curtain attenuation will be used during impact driving of steel piles in water
dB = decibels
MOF = Material Offloading Facility
NMFS = National Marine Fisheries Service
NE = Not Exceeded
RMS = root mean square
TPP = TransPacific Parkway
SEL = Sound Exposure Limit

Table 1-2
Estimated Pile-Driving Noise Levels and Distances of Level B Threshold Exceedance with Impact and Vibratory Driver

Project Element Requiring Pile Installation	Source Levels at 10 meters (dB)		Distance to Level B Threshold, in meters[1]
	Peak	RMS	160/120 dB RMS[2]
Marine Facilities			
Sheet Piles at MOF/West Berth wall and 24-inch TMBB Mooring Piles – Vibratory in-the-dry	--[4]	--[4]	1,914
Ancillary Activities			
24-inch Pipe Piles at TPP/US-101 Impact with BCA	201	177	136
14-inch Timber Piles at TPP/US-101– Impact within cofferdam	180	170	46
24-inch Pipe Piles at TPP/US-101, and APCO sites – Vibratory in-water	191	165	10,000
14-inch Timber Piles at TPP/US-101 – Vibratory within cofferdam	172	162	6,310
Sheet Piles at TPP/US-101 – Vibratory in-water	175	160	4,642

Notes:

[1] Where noise will not be blocked by land masses or other solid structures.

[2] For underwater noise, the Level B harassment (disturbance) threshold is 160 dB for impulsive noise (i.e. impact driving) and 120 dB for continuous noise (i.e. vibratory driving).

[4] Since these piles will be driven on land, source values at 10 meters are not available; distances are calculated by JASCO modeling

Peak and RMS are re: 1 µPa.

BCA = Bubble curtain attenuation will be used during impact driving of steel piles in water.
µPa = microPascal
dB = decibels
TPP = TransPacific Parkway
MOF = Material Offloading Facility
RMS = root mean square

4.0 PILE INSTALLATION LOCATION

The LNG Terminal site is in Coos County, Oregon, on the bay side of the North Spit of Coos Bay at about CM 7.3, along the existing FNC (Figure 1), at the beginning of the confluence between the Jarvis Turn and the Upper Jarvis Range A.

Other project components would include the following:

- The access channel would encompass approximately 8.9 hectares below the high mean tide elevation of 3.13 feet (North American Vertical Datum of 1988 [NAVD88]).
- The proposed marine slip would be just north of the proposed access channel, and west and south of the LNG terminal site. The site currently is upland, and it would be excavated behind an earthen berm and dredged to a final depth of approximately -13.7 meters NAVD88.
- The MOF would encompass approximately 1.2 hectares on the southeastern side of the slip.
- The TMBB would be on the shoreline at the southwestern area of the earthen berm and eventual southwestern side of the slip, where it connects to the access channel. This site would be removed during excavation of the berm.
- The NRIs of the FNC would be at four locations between the mouth of the Coos Bay estuary and the LNG Terminal site.
- TPP/US-101 would be in the northern reaches of the estuary, near Haynes Inlet and north of APCO Sites 1 and 2
- APCO Sites 1 and 2 would be east of the Southwest Oregon Regional Airport, across the bay from the LNG Terminal site.
- The Kentuck site would be on the eastern shore of Coos Bay, at the mouth of Kentuck Slough.
- The Eelgrass Mitigation site would be just southwest of the Southwest Oregon Regional Airport.

During the Year 1 construction season, piles that could generate noise levels exceeding the NMFS thresholds would be driven at the MOF, the TMBB, the southwestern corner of the marine slip, TPP/US-101, and APCO Sites 1 and 2 (Figure 1). Pile Driving would not occur at the other locations in Year 1.

Table 2 summarizes the pile driving associated with the LNG Terminal that would be conducted during Year 1. These components are described in more detail in Section 1.2 of the IHA application. Table 2 also shows the pile driving associated with the Ancillary Activities, described in Section 1.3 of the IHA application. Only the installation of piles associated with the TPP/US-101 widening and APCO Sites 1 and 2 would occur during Year 1. All piles would be driven in the water, except the timber piles at TPP/US-101, which would be driven behind a partially dewatered cofferdam. All impact driving of in-water pipe piles would be done within a bubble curtain.

JCEP currently anticipates that construction of the LNG Terminal would begin in the second half of 2020, with a target in-service date in the first half of 2024. This Plan is tailored for the pile-driving activities that are scheduled to occur in the first year of construction (October 2020 to October 2021). Conformance to the ODFW regulatory in-water work window for dredging and in-water impact driving would be implemented to reduce impacts on listed fish species, per other permitting authorities. The in-water work window is from October 1 to February 15, and the period outside the in-water work window is from February 16 to September 30. For this IHA application, the work windows also are used to inform seasonal differences in the local abundance and density of harbor seals in Coos Bay. The in-water work window also would avoid the pupping season for harbor seals. For that purpose, the items shown in Table 2 are broken down by the in-water work window and the period outside the in-water work window. In-the-dry and in-water vibratory pile driving may occur year-round at the LNG Terminal.

Some pile-driving activities would be scheduled to occur simultaneously. Although only one pile-driving rig is expected to be active at any single work location, pile driving may occur simultaneously at multiple locations. For example, the sheet piling installation at the MOF location may occur at the same time that the cofferdam sheet piles are being installed at TPP/US-101; however, these locations are at least 3 kilometers apart (Figure 1).

Table 2. Year 1 Piling/Sheet Piling Installation Schedule

Method	Pile Type	In-the-dry or In-water	Total Piles	Location	Driving Days[a]	Minutes of Driving per Day
LNG Terminal						
Vibratory	Sheet Pile	In-the-dry	1,246	MOF (outside in-water work window)	97	309
Vibratory	Sheet Pile	In-the-dry	623	MOF (inside in-water work window)	48	309
Vibratory	Sheet Pile	In-the-dry	113	W. berth wall, 2.5% nearest berm (outside in-water work window)	8.5	329
Vibratory	24-inch Pipe Pile	In-the-dry	6	TMBB mooring pile (inside in-water work window)	10	9
Ancillary Activities (all would occur inside in-water work window)						
Impact	Timber	In-water (behind cofferdam)	1,150	TPP/US-101 intersection	60	50
Vibratory					60	100
Vibratory	Sheet Pile	In-water	311	TPP/US-101 intersection	16	100
Impact	Pipe Pile	In-water (with BCA)	36	TPP/US-101 intersection	9	20
Vibratory					9	80
Vibratory	Pipe Pile	In-water	33	APCO sites	9	30

Notes:

a. May occur concurrently with other pile-driving activities

BCA – Bubble Curtain Attenuation or equivalent

LNG Terminal – Liquid Natural Gas Terminal

MOF – Material Offloading Facility

TMBB – Temporary Material Barge Berth

TPP/US-101 – TransPacific Parkway/U.S. Highway 101

When the scheduling constraints of the in-water work window is considered, the estimated number of actual days when pile driving would occur is approximately 230 days for the 2020–2021 construction season. For the first year, the periods of activity associated with the pile driving that may result in take of marine mammals are shown in Table 2. None of the temporary piles associated with the Ancillary Activities would be removed during the 2020–2021 construction season.

5.0 PILE INSTALLATION AND MONITORING SCHEDULE

For the 2020 construction season, hydroacoustic monitoring will be conducted for a portion of all piles to be installed by impact or vibratory methods. In general, approximately 5 percent of each pile driving activity would be monitored, with a minimum of three and a maximum of 20 piles monitored. Table 3 shows the monitoring for the 2020–2021 construction season. Piles chosen to be monitored should be driven in areas closer to the shoreline for in-the-dry driving, or in deeper water depths for in-water driving where more potential exists for underwater noise to be transmitted into the water column.

Table 3. Year 1 Piling/Sheet Piling Monitoring Requirements

Method	Pile Type (size)	General Location	Piles to be Monitored	Specific Location	Total Pile Count
LNG Terminal					
Vibratory	Pipe Pile (24-inch)	TMBB mooring pile	3	In-the-dry – Piles closest to shoreline	6
Impact			3		
Vibratory	Sheet Pile (NA)	MOF	20	In-the-dry – MOF face parallel to shoreline	1,246
Vibratory	Sheet Pile (NA)	MOF	20	In-the-dry – Sheet pile tie-back along length	623
Vibratory	Sheet Pile (NA)	W. berth wall	6	In-the-dry –Piles closest to shoreline	113
TPP/US-101 Widening					
Impact	Timber (14-inch)	TPP/US-101 intersection	20	Roadway Grid – Piles installed at lowest location (~ MLLW)	1,150
Vibratory	Sheet Pile (NA)	TPP/US-101 intersection	15	Cofferdam – Piles installed at lowest location (~MLLW)	311
Impact	Pipe Pile (24-inch)	TPP/US-101 intersection	3	Work Access Bridge – Piles installed at lowest location (~MLLW)	36
Vibratory			3		
APCO 1 and APCO 2 Sites					
Vibratory	Pipe Pile (24-inch)	APCO Site	3	APCO sites – Piles installed at lowest location (~MLLW)	12
Vibratory	Pipe Pile (24-inch)	APCO Site	3	APCO sites – Piles installed at lowest location (~MLLW)	5
Vibratory	Pipe Pile (24-inch)	APCO Site	3	APCO sites – Piles installed at lowest location (~MLLW)	16

Notes:

a. May occur concurrently with other pile-driving activities

BCA – Bubble Curtain Attenuation or equivalent

LNG Terminal – ligiid Natural Gas Terminal

MOF – Material Offloading Facility

NA – Not Applicable

TMBB – Temporary Material Barge Berth

TPP/US-101 – TransPacific Parkway/U.S. Highway 101

6.0 CONTRACTOR AND EQUIPMENT REQUIREMENTS

The acoustic monitoring contractor will have appropriate qualifications, which include a minimum of a bachelor's degree in a related field[1] and 3 years of experience in noise monitoring and analysis.. The contractors' proposed sound level monitoring equipment shall meet or exceed the specifications shown in Table 4. The measurement range in terms of amplitude (in decibels [dB], referenced to 1 microPascal [1 uPa]), sensitivity, and frequency shall be stated. A minimum frequency range of 20 hertz (Hz) to 20 kilohertz (kHz) and a minimum sampling rate of 24 kHz will be used when monitoring. Table 4 shows the minimum requirements of the equipment to be used. In addition to the equipment selection, quality control/quality assurance procedures should be described (e.g., how will system responses be verified and how will data be managed).

Table 4. Example Equipment for Underwater Sound Monitoring

Item[a]	Specifications	Minimum Quantity	Usage
Hydrophone	Receiving Sensitivity- -211dB re 1V/µPa	1	Capture underwater sound pressures near the source and convert to voltages that can be recorded/analyzed by other equipment.
Hydrophone	Receiving Sensitivity – -200dB re 1V/µPa	1	Capture underwater sound pressures for background levels and convert to voltages that can be recorded/analyzed by other equipment.
Signal Conditioning Amplifier	Amplifier Gain- 0.1 mV/pC to 10 V/pC Transducer Sensitivity Range- 10-12 to 103 C/MU	1	Adjust signals from hydrophone to levels compatible with recording equipment.
Calibrator (pistonphone-type)	Accuracy- IEC 942 (1988) Class 1	1	Calibration check of hydrophone in the field.
Digital Signal Analyzer	Sampling Rate- 24kHz or greater	1	Analyzes and transfers digital data to laptop hard drive.
Microphone (free field type)	Range- 30 – 120 dBA Sensitivity- -29 dB ± 3 dB (0 dB = 1 V/Pa) Wind Screen	1	Monitoring airborne sounds from pile driving activities (if not raining).
If water velocity ~> 1m/s, flow shield	Open cell foam cover or functional equivalent	1/hydrophone	Eliminate flow noise contamination.
Laptop computer or Digital Audio Recorder	Compatible with digital signal analyzer	1	Record digital data on hard drive or digital tape.
Real time and post-analysis software	-	1	Monitor real-time signal and post-analysis of sound signals.

Notes:

[1] This can include Institute of Noise Control Engineering of the USA certification or related fields such as acoustics, physics, oceanography, geology, or other physical sciences that have required coursework in physics.

a. All have current National Institute of Standards and Technology traceable calibration. This table is intended as a guideline and exact specifications can be adjusted to meet the needs of the individual project or contractor equipment.

To facilitate further analysis of data full bandwidth, time-series underwater signal shall be recorded as a text file (.txt) or wave file (.wav), or a similar format. Recorded data shall not use data compression algorithms or technologies (e.g., MP3, compressed .wav). Underwater acoustic data shall be backed up on a secondary drive.

7.0 METHODOLOGY

7.1 Calibration Procedure

The hydrophone calibrations will be checked at the beginning of each day of monitoring activity. Calibration of measurement systems will be established before use in the field each day. An acoustical piston phone and hydrophone coupler will be used supported by manufacturer calibration certificates. Calibration of measurement systems will be established using an acoustically certified piston phone and hydrophone coupler that fits the hydrophone and that directly calibrates the measurement system. The volume correction of the hydrophone coupler using the hydrophone is known, and thus the piston phone produces a known signal that can be compared against the measurement system response. The response of the measurement system will be noted in the field book and applied to all measurements.

The Amplifier and Digital Signal Analyzer will be calibrated or checked to the calibration tone prior to use in the field. The tone will then be measured and recorded at the beginning of the digital audio recordings that will be used. The system calibration status will be checked by measuring the calibration tone and recording the tones. The recorded calibration tones will be used for subsequent detailed analyses of recorded pile strike sounds. National Institute of Standards and Technology (NIST) traceable calibration forms will be provided for all relevant monitoring equipment. Before initiation of pile driving, the hydrophone will be placed at the appropriate distance and depth, as described above.

7.2 Hydrophone Deployment and Use

Two hydrophones will be placed for each monitoring event, one placed close to the pile and one placed at a greater distance so that a transmission loss value can be measured. For in-water pile driving, the hydrophone nearest the pile will be placed at least 3H from the pile, where H is the water depth at the pile and 0.7 to 0.85H depth from the surface, or 10 meters, whichever is greater (NMFS 2012b). For all pile driving, including in-the-dry pile installation, hydrophones will be placed at least 1 meter below the surface and with a clear acoustic line-of-sight between the pile and the hydrophone. The other hydrophone will be placed at mid-column depth, at a distance at least 20 times the source depth or 50 meters from each pile being monitored, whichever is greater, in waters at least 5 meters deep (NMFS 2012a). If the monitoring location has a current velocity ≥ 1.5m/sec, flow noise may influence measurements. Best practices to minimize flow noise include deploying the hydrophone at a depth close to the bottom (but at least 4m off the bottom) or use of a flow shield made of latex or spandex that does not trap air (NMFS 2012a).The hydrophones will be attached to a nylon cord, a steel chain, or other proven anti-strum features, if the current is swift enough to cause strumming of the line. The nylon cord or chain will be attached to an anchor that will keep the line the appropriate distance from each pile. The nylon cord or chain will be attached to a float or tied to a static line at the surface. The distances will be measured by a tape measure, where possible, or a laser range-finder. The acoustic path (line of sight) between the pile and the hydrophone(s) should be unobstructed in all cases.

The on-site inspector/contractor will inform the acoustics specialist when pile driving is about to begin, to ensure that the monitoring equipment is operational. Underwater sound levels will be monitored continuously during the entire duration of each pile being driven, with a minimum one-third octave band frequency resolution. The wideband instantaneous absolute peak pressure and sound exposure level (SEL) values of each strike, and daily cSEL should be monitored in real time during construction, to ensure that the project does not the modeled distances to harassment thresholds (Tables 1-1 and 1-2). Peak and RMS pressures will be reported in dB (1 µPa). SEL will be reported in dB (1 μPa^2 per second). Wideband time series recording is strongly recommended during all impact pile driving.

Underwater sound levels will be continuously monitored during the entire duration of each pile being driven. During impact driving, the peak, root-mean-square (RMS) (impulse level), and SEL of each strike will be monitored in real time, and during vibratory driving, a 10-second integration of RMS and SEL will be monitored. The cumulative SEL (cSEL) also will be monitored live, assuming no contamination from other noise sources. Underwater sound levels will be measured in dB (1 µPa).

Before and during pile-driving activity, environmental data will be gathered, including wind speed and direction, air temperature, water depth, wave height, sea state using the Beaufort scale, weather conditions, and other factors (e.g., aircraft or boats) that could contribute to influencing the underwater sound levels. The start and stop time of each pile driving event will be recorded.

Just before any pile driving activity starts, ambient underwater sound levels will be measured for a minimum of 1 minute, in the absence of construction activities, to determine background levels. Ambient levels will be reported as RMS and include a spectral analysis of the frequencies.

When collecting sound measurements in an area with currents (i.e., in rivers or tidally influenced areas), appropriate measures will be taken, when necessary, to ensure that the flow-induced noise at the hydrophone will not interfere with the recording and analysis of the relevant sounds (NMFS 2012a). As a general rule, current speeds of 1.5 meters per second or greater are expected to generate significant flow-induced noise, which may interfere with the detection and analysis of low-level sounds, such as the sounds from a distant pile driver or background sounds.

If it becomes necessary to reduce the flow-induced noise at the hydrophone, a flow shield will be installed around the hydrophone, to provide a barrier between the irregular, turbulent flow and the hydrophone. If no flow shield is used in these situations, the current velocity will be measured, and a correlation between the levels of the relevant sounds (background or pile driving) and current speed will be made to determine whether the data was valid and can be included in the analysis. Whether or not the flow shield is used will be recorded in the data.

7.3 Background Noise Monitoring

No more than 60 days prior to the start of Year 1 pile driving activities, background underwater sound levels will be measured for a minimum of three full 24-hour cycles (i.e., 6 a.m. to 6 a.m.) during a typical weekday period, in the absence of construction activities, to determine background sound levels (NMFS 2012a). Analysis will be conducted, using both data from the full range of frequencies recorded (typically 20 Hz to 20 kHz) and high pass filters at 7 Hz, 75 Hz, and 150 Hz, and thus eliminating frequencies below these levels (NMFS 2012a), which follows the marine mammal functional hearing groups of Southall et al. (2007). The data will be used to calculate 30-second RMS values for each 30 seconds of the three 24-hour cycles measured. These data will be used to calculate and plot a Cumulative Distribution Function (CDF) (NMFS 2012a). Overall background sound levels will be reported as the 5th, 50th, and 95th percentile CDF and will include a spectral analysis of the frequencies (NMFS 2012a) for a minimum of a 1-hour cycle. More details on the cumulative distribution function are provided in Appendix B. The average RMS of the background noise will be calculated for each marine mammal functional hearing group, as reported by Southall et al. (2007; NMFS 2012b). Since construction would occur during the daytime, the background noise reporting would focus on daytime background noise levels on a typical day that is representative of conditions one would expect during pile driving activities.

8.0 SIGNAL PROCESSING

8.1 Impact Pile Driving

Post-analysis of the underwater pile driving sounds will include:

- number of pile strikes per pile and per day;
- for each recorded strike, determination of the following:
  - peak pressure, defined as the maximum absolute value of the instantaneous pressure (overpressure or underpressure),
  - RMS sound pressure integrated across 90 percent of each waveform ($RMS_{90\%}$) using the 5-95 percentiles to establish the 90% criterion, and
  - SEL, measured across 90 percent of the accumulated sound energy ($SEL_{90\%}$) (The calculation methodology is provided in Appendix A.);
- maximum, mean, and range of the peak pressure, with, and if applicable, without attenuation;
- maximum, mean, range, and CDF of the $RMS_{90\%}$, both with and if applicable, without attenuation where the CDF would be used to report the percentage of $RMS_{90\%}$ values above the thresholds;
- maximum, mean, and range of the $SEL_{90\%}$, both with and if applicable, without attenuation;
- the cSEL across all of the pile strikes (If SEL is calculated for all strikes, cSEL would be estimated as provided in Appendix A. If SEL is calculated for a subset of strikes, cSEL would be estimated as follows: $cSEL = SEL_{mean} + 10*\log$ (total number of strikes);
- where a subset of piles are monitored to represent a larger project, an estimate of the cSEL during a typical day of construction driving must be reported by summing the SEL over the expected number of pile strikes in a typical day for the larger project: $cSEL = SEL_{mean} + 10*\log$ (number of strikes), and the SEL_{mean} used in this calculation must correspond with the actual sound attenuation measures that will be used during construction of the larger project; and
- a frequency spectrum both with and, *if applicable*, without attenuation, between a minimum of 20 and 20 kHz for up to eight successive strikes with similar sound levels.

8.2 Vibratory Pile Driving

Vibratory monitoring data will be analyzed by calculating 10-second average RMS values every 10 seconds for each pile. Then the 10-second RMS values will be averaged for the entire pile and reported as the average RMS.

9.0 ANALYSIS

9.1 Impact Pile Driving

Analysis of the data from the San Francisco–Oakland Bay Bridge Pile Installation Demonstration project indicated that 90 percent of the acoustic energy for most pile driving impulses occurred over a 50 to 100 millisecond period, with most of the energy concentrated in the first 30 to 50 milliseconds (Illingworth and Rodkin 2001). The RMS values to be computed for this project would be computed between the time when 5 and 95 percent of the energy of the pulse occurs. The SEL energy plot will assist in interpretation of the single-strike waveform. The single-strike SEL associated with the highest absolute peak strike, along with the total number of strikes per pile and per day, will be used to calculate the cumulative SEL for each pile and each 24-hour period. When suitable data is available, a transmission loss value will be computed for each monitored pile based on the falloff that occurs between the two monitoring distances. Units of underwater sound pressure levels will be dB (1 µPa), and units of SEL would be 1 μPa^2 per second.

9.2 Vibratory Pile Driving

Vibratory monitoring results will include the maximum and average RMS values for each pile monitored and a comparison of the frequency content between piles. The maximum and overall average RMS, calculated from 10-second RMS values during the pile driving, will be calculated and SEL energy plots and spectral plots of representative vibratory pile driving will also be developed. When suitable data is available, a transmission loss value will be computed for each monitored pile based on the falloff that occurs between the two monitoring distances.

10.0 COORDINATION AND REPORTING

While acoustic monitoring is occurring, coordination with the Marine Mammal Observers (MMO) will occur in order to verify shutdown zone distances from the pile. In order to establish good protocols for coordination, the MMO team(s), hydroacoustic monitoring team(s), and other biological monitoring teams shall establish a line of communication between the biological monitoring teams, Jordan Cove and the contractor(s) prior to the start of pile driving. This communication plan will include provisions such that if any hydroacoustic measurements find that Level A thresholds are being exceeded outside of the established shutdown zones, the pile driving producing the noise exceeding the threshold will stop, and the MMOs will be immediately notified so a larger shutdown zone can be established. Daily summaries of sound levels will be provided to the MMOs when hydroacoustic monitoring occurs. If hydroacoustic monitoring indicates that smaller shutdown or monitoring zones can be established, the MMO team(s) shall coordinate with NMFS to receive approval before any zone sizes are decreased.

The pile-driving contractor will provide the following information in writing to the contractor conducting the hydroacoustic monitoring, for inclusion in the final monitoring report: a description of the substrate composition, approximate depth of significant substrate layers, hammer model and size, pile cap or cushion type, hammer energy settings and any changes to those settings during the piles being monitored, depth pile driven, blows per foot for the piles monitored, and total number of strikes to drive each pile that is monitored.

A draft report, including data collected and summarized from all monitoring locations, will be submitted to NMFS within 90 days of completion of the hydroacoustic monitoring for Year 1. The results will be summarized in graphical form and will include summary statistics and time histories of impact sound values for each pile. A final report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS. The report shall include:

- size and type of piles;
- a detailed description of the bubble curtain, including design specifications;
- the hammer energy rating used to drive the piles, and the make and model of the hammer;
- a description of the sound monitoring equipment;
- the distance between hydrophones and pile, and for in-the-dry pile driving, the distance of the pile from the shoreline;
- the depth of the hydrophones and depth of the water at the hydrophone locations;
- location of the pile;
- for in-the-dry locations, the distance from the pile to the water's edge;
- for in-water locations, the depth of water in which the pile is driven;
- the depth into the substrate that the pile is driven;
- the physical characteristics of the bottom substrate into which the piles are driven;
- the total number of strikes (impact driving) or seconds (vibratory driving) to drive each pile and for all piles driven during a 24-hour period;
- the underwater, wideband background, sound pressure level, reported as the 5^{th}, 50^{th}, and 95^{th} percentile CDF;
- the results of the hydroacoustic monitoring, as described under Signal Processing and Analysis (an example table is provided in Appendix C for reporting the results of the monitoring);

- the distance at which the measured peak, cSEL, and RMS values exceed the respective threshold values; and
- the vibratory monitoring results, including the maximum and overall average RMS calculated from 10-second RMS values.

11.0 REFERENCES

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Appendix A
Calculation of Cumulative SEL

An estimation of individual SEL values could be calculated for each pile strike by calculating the following integral, where T is T_{90}, the period containing 90 percent of the cumulative energy of the pulse (eq. 1).

$$SEL = 10 \log \left(\int_0^T \frac{p^2(t)}{p_0^{\,2}} dt \right) \quad dB \qquad \text{(eq. 1)}$$

Calculating a cumulative SEL from individual SEL values cannot be accomplished simply by adding each SEL decibel level arithmetically. Because these values are logarithms, they first must be converted to antilogs and then accumulated. If the single strike SEL is very close to a constant value (within 1 dB), then cumulative SEL = single strike SEL + 10 times log base 10 of the number of strikes N (i.e., 10Log10[N]). However, if the single strike SEL varies over the sequence of strikes, then a linear sum of the energies for all the different strikes needs to be computed. This is done as follows: divide each SEL decibel level by 10 and then take the antilog. This will convert the decibels to linear units (or uPa^2●s). Next, compute the sum of the linear units and convert this sum back into dB by taking 10Log10 of the value. This will be the cumulative SEL for all of the pile strikes. (FHWG 2013)

Appendix B
Calculation of a Cumulative Distribution Function and Plot for Background Sound Level Analysis

Data from three full 24-hour underwater measurement cycles (minimum) are used to calculate a 30-second Root Mean Square (RMS) value for each 30-second period for the entire dataset. The RMS should be calculated for both the full frequency range recorded as well as a separate dataset which has been passed through a high pass filter, thus eliminating those frequencies below 1,000 hertz. These datasets then are grouped into 24-hour periods. To determine whether the data is approximately log-normal in distribution, each 24-hour period is plotted as a Probability Density Function (PDF). Each 24-hour period can be plotted on the same PDF plot. The plots should be approximately log normal in distribution, and thus can be used in the further analysis. Each day of data should have an approximately Gaussian sigmoid shape. The differences between them and the ideal may be difficult to detect visually, but the sigmoid from day to day will show noticeable variation. Data that does not approximate a log normal distribution should be excluded from further analysis.

The Cumulative Distribution Function (CDF) plot is obtained by plotting the normalized cumulative sum versus the bin location (Figure B-1). The PDF also can be obtained from plotting the normalized bin count versus the bin location. The normalized bin count is obtained by dividing the count column by the number of data points multiplied by the space between 2 consecutive bins. This will provide the integral of the PDF equal to 1. Instructions on creating a histogram in Microsoft Excel are available online at http://www.vertex42.com/ExcelArticles/mc/Histogram.html.

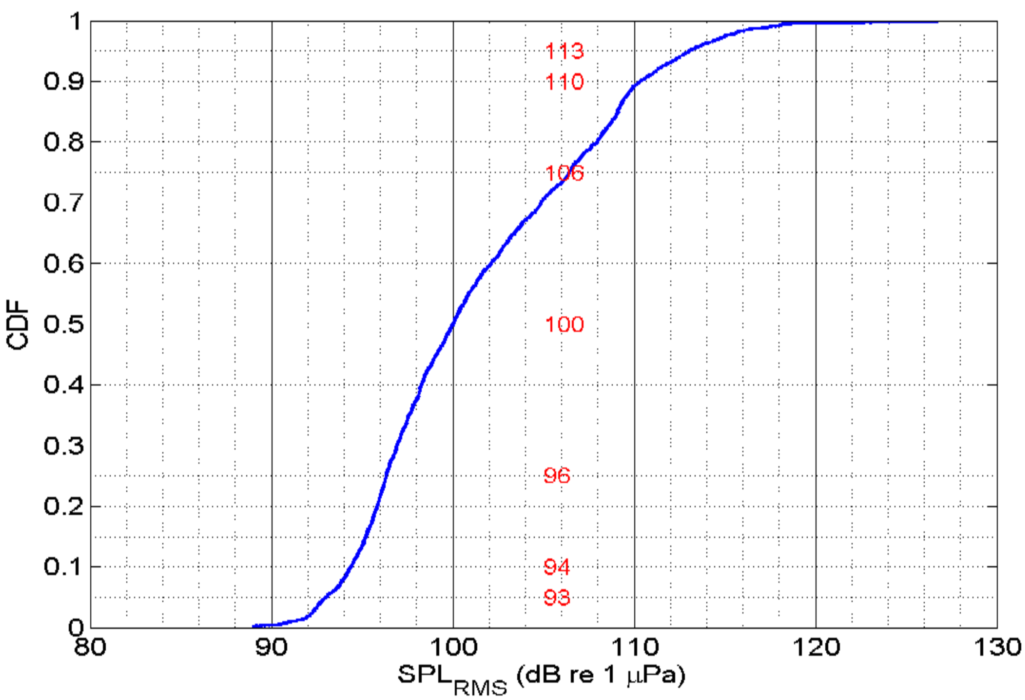

Figure B-1. Cumulative Distribution Function Plot

Appendix C
Reporting for Hydroacoustic Monitoring

Example Reporting Table for Hydroacoustic Monitoring

Date and Time	Pile ID	Hammer Impact or Vibratory	# Strikes or Vibratory Seconds	Distance to Pile from Hydrophone (m)	Water Depth (m)		Peak (dB)			$SEL_{90\%}$ (dB)				$RMS_{90\%}$ (dB)			Notes
					At Pile	At H-phone	Max	Min	Mean	Max	Min	Mean	$cSEL_{90}$%	Max	Min	Mean	