APPLICATION

Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Application for a Marine Mammal Protection Act Incidental Harassment Authorization

Prepared for the

Port of Alaska

2000 Anchorage Port Road
Anchorage, Alaska 99501

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Acronyms and Abbreviations

ADF&G	Alaska Department of Fish and Game
ARRC	Alaska Railroad Corporation
AWC	Anadromous Waters Catalog
Caltrans	California Department of Transportation
CFR	Code of Federal Regulations
CIMMC	Cook Inlet Marine Mammal Council
dB	Decibels
dBA	A-weighted Decibels
DOT&PF	Alaska Department of Transportation and Public Facilities
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FHWA	Federal Highway Administration
FR	*Federal Register*
ft	feet
GIS	Geographic Information System
HF	High Frequency
Hz	Hertz
ICRC	Integrated Concepts and Research Corporation
IHA	Incidental Harassment Authorization
iPCoD	Interim Population Consequences of Disturbance
JBER	Joint Base Elmendorf-Richardson
KABATA	Knik Arm Bridge and Toll Authority
kHz	Kilohertz
km	Kilometer(s)
km^2	Square Kilometer(s)
L_{pk}	Peak Sound Level
LF	Low Frequency
LOA	Letter of Authorization
µPa	MicroPascal(s)
mi^2	Square Mile(s)
MF	Mid-Frequency
MLLW	Mean Lower Low Water

MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MOA	Municipality of Anchorage
MTRP	Marine Terminal Redevelopment Project
NITS	Noise-Induced Threshold Shift
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
OSP	Optimum Sustainable Population
OW	Otariid in Water
PAMP	Port of Alaska Modernization Program
POL 1	Petroleum Oil Lubricants
PCE	Primary Constituent Element
PCT	Petroleum and Cement Terminal
POA	Port of Alaska
PTS	Permanent Threshold Shift
PW	Phocid in Water
R^2	Coefficient of Determination
rms	Root Mean Square
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SPL	Sound Pressure Level
SSL	Sound Source Level
TL	Transmission Loss
TPP	Test Pile Program
TTS	Temporary Threshold Shift
URS	URS Corporation
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDOT	U.S. Department of Transportation
WEAP	Wave Equation Analysis of Pile Driving
WSDOT	Washington State Department of Transportation

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1 Description of Activities

1.1 Introduction

The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) regulations governing the issuance of Incidental Harassment Authorizations (IHAs) and Letters of Authorization (LOAs) permitting the incidental, but not intentional, take of marine mammals under certain circumstances are codified in 50 Code of Federal Regulations (CFR) Part 216, Subpart I (Sections 216.101–216.108). The Marine Mammal Protection Act (MMPA) defines take to mean "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S. Code [USC] Chapter 31, Section 1362 (13). Section 216.104 sets out 14 specific items that must be addressed in requests for rulemaking and renewal of regulations pursuant to Section 101(a)(5) of the MMPA. Those 14 items are addressed in this application for two IHAs.

The Port of Alaska (POA) requests authorization for the take of small numbers of marine mammals, by Level A and Level B harassment, incidental to construction of the Petroleum and Cement Terminal (PCT) near its existing port facility in Anchorage, Alaska. The project will occur over 2 construction seasons, or two phases. Estimates of take were determined based on construction of each phase. The POA requests an IHA that is valid for 1 year, from 01 April 2020 through 31 March 2021 (Phase 1), and a second IHA that is valid for a second construction season for 01 April 2021 to 31 March 2022 (Phase 2).

In this IHA application, the units of measure reported for construction are U.S. customary units, which are typically used in construction. Units of measure for scientific information, including acoustics, are metric. When appropriate, units are reported as both U.S. customary and metric.

1.2 Project Purpose and Need

The PCT is part of an overall reconstruction plan for the POA, referred to as the Port of Alaska Modernization Program (PAMP). Located within the Municipality of Anchorage on Knik Arm in upper Cook Inlet, the existing infrastructure and support facilities were constructed largely in the 1960s. Port facilities are substantially past their design life, have degraded to levels of marginal safety, and are in many cases functionally obsolete, especially in regard to seismic design criteria and condition. The PAMP will include construction of new pile-supported wharves and trestles to the south and west of the existing terminals, with a planned design life of 75 years.

The POA is an intermodal transport hub that efficiently links marine, road, rail, pipeline and air cargo systems to connect communities, military bases and other destinations across the state. It serves deep-draft vessels that operate year round to transport cargo faster, cheaper and more reliably than any other means. It is Alaska's only National Strategic Seaport, one of 23 nationwide. It is a critical piece of national defense infrastructure.

The Port is the primary entry point for fuel and cement in Alaska. The transportation and construction sectors of the Alaska economy rely upon the fuel and cement that comes through the Port to maintain their ongoing business operations. Joint Base Elmendorf Richardson (JBER) relies on the jet fuel that is delivered across the dock to support all their United States Air Force (USAF) flight activities. Bulk fuel and cement is transported from the Port by rail and road to facilities in both urban and rural towns across Southcentral and Interior Alaska. Fuel and cement are also trans-loaded onto barges for shipment to the rural towns and villages in Southeast, Southwest, and Northern Alaska.

The purpose for the PCT project is to replace the existing POL 1, the only bulk cement-handling facility in Alaska and the primary terminal for receipt of refined petroleum products. POL1, built in 1965, is more than 50 years old and consists of 160 wharf pilings that are uncoated, hollow-steel pile. The need for the PCT is based on the heavily deteriorated physical condition of POL1. It suffers from severe corrosion of its foundation pilings to levels of marginal safety, as evidenced by currently imposed load restrictions. A 2014 pile condition assessment found severe corrosion throughout the facility, with pile wall losses exceeding 67 percent of their original thickness. It also sustained structural damage from a magnitude 7.1 earthquake that struck the area on November 30, 2018. Recent inspections in 2019 have led engineers to confirm the stress imposed on the already-weakened structure by the November 30 quake caused some piling failure and predisposes the docks to additional failure during future earthquakes. The PCT has been designed to satisfy project-specific seismic performance criteria, allowing the terminal to be quickly restored to service following a major seismic event. POL1 is functionally obsolete, has exceeded its useful life and is unlikely to survive another such earthquake.

The Port is also the only facility in the state that can transfer cement from bulk carriers in un-sacked powder form. Approximately 87 percent of the cement used for construction in the state comes into the Port annually, with POL1 being the only facility capable of supporting this operation. In 2018, 105,000 tons of Portland cement powder was transferred from vessels across POL1 to Alaska Basic Industries Port storage facilities. Post-disaster reconstruction for Alaskans will be highly dependent on capability to receive bulk shipments of cement. A new PCT will provide the necessary capability because it will be built to high standards for seismic resilience.

POL1 is a key infrastructure asset that supports essential elements of Alaska's fuel supply. In 2018, 11.1 million barrels of petroleum products were unloaded from vessels through these bulk cargo terminals. Approximately 49 percent of the fuel for air carriers operating at Ted Stevens Anchorage International Airport (TSAIA) is brought into the state through the Port. Aviation fuels are stored at the Port and transported to TSAIA in fuel trucks (Aviation Gasoline or Avgas) and by a small diameter pipeline (Jet Fuel). This fuel is critical to TSAIA's operations, which in turn is critical to Alaska and beyond. TSAIA's passenger traffic has hovered around the 5 million mark for the last 10 years. TSAIA is North America's second busiest airport as ranked by landed cargo tonnage. One in ten Anchorage jobs depends on TSAIA. Any significant disruption of fuel supplies would harm TSAIA cargo handling operations, the local economy, and national and international commerce. Likewise, the Fairbanks International Airport (FAI) depends upon fuel delivered across the docks of the Port of Alaska.

If POL1 fails before a replacement is available, the transportation challenges of moving these products become almost insurmountable, because there are no other facilities in Southcentral Alaska with similar facilities or capacity.

There is no reasonable alternative to modernizing the Port because it cannot be economically replaced elsewhere. Unique attributes include:

- Port facilities leverage hundreds of millions of dollars of port-related infrastructure, including freight and fuel handling, storage and transport facilities and pipelines that supply virtually all jet fuel used at Ted Stevens Anchorage International Airport and Joint Base Elmendorf-Richardson (JBER).
- Proximity of Alaska population centers, transportation infrastructure and JBER.
- Upper Cook Inlet geography virtually eliminates tsunami hazards.
- All other Southcentral Alaska deep-water ports and alternative transport modes combined do not have the inbound-cargo-handling capacity to cost-effectively replace the Port of Alaska.

In addition, maintaining the existing facilities is not a reasonable alternative. Anchorage budgets $3 million annually for the Port to install pile jackets/steel sleeves around corroded sections of piles to help maintain operational capacity, but these repairs do little to enhance operational efficiency or earthquake survivability. These jackets extend the life of each pile by only 10-20 years at best and cannot be replaced. The sleeves address the reduced axial capacity of the corroded piles but to not address seismic concerns. Consequently, the Port will have to continue reducing load capacities at the existing docks and then close some docks starting in about 10 years, regardless of seismic activity.

1.3 Project Description

The PCT will be a new pile-supported structure located along the southernmost shoreline of the POA (Figure 1-1 and Figure 1-2) and construction will occur during two phases, Phase 1 and Phase 2, over two construction seasons in 2020 and 2021. The POA's boundaries currently occupy an area of approximately 129 acres. Other commercial and industrial activities related to secured maritime operations are located near the POA on Alaska Railroad Corporation (ARRC) property immediately south of the POA, on approximately 111 acres. The PCT terminal footprint spans approximately 0.87 acres and is approximately 0.74 kilometer (0.46 mile) north of Ship Creek, a location of concentrated marine mammal activity during seasonal runs of several salmon species.

The PCT Project will involve new construction of a loading platform, access trestle, and dolphins (catwalks will connect the dolphins); and installation of utilities (electricity, water, and communication), petroleum, and cement lines linking the terminal and shore (Table 1-1). Ships mooring to the PCT will utilize both breasting dolphins and mooring dolphins to secure vessels to the loading platform. To meet required structural demands, 144-inch-diameter monopile dolphins are planned for both the breasting and mooring dolphins. Breasting dolphins are designed to assist in the berthing of vessels by absorbing some of the lateral load during vessel impact. Breasting dolphins also protect dock platforms from impacts by vessels. Mooring dolphins, as their name implies, are used for mooring only and provide a place for a vessel to be secured by lines (ropes). Use of mooring dolphins helps control transverse and longitudinal movements of berthed vessels.

In addition to these permanent structures, temporary work including temporary pile installation will be required to accommodate construction. During Phase 1, a temporary construction access trestle will be installed immediately adjacent and parallel to the permanent access trestle, and then subsequently removed when the permanent access trestle and loading platform construction are completed. During both Phase 1 and Phase 2, temporary template piles and mooring piles will also need to be installed. Various work boats and barges will be utilized to support construction and will be moored at or in the immediate vicinity of the PCT Project.

In-water pile driving and removal is anticipated to take approximately 202 days to complete (127 days for Phase 1 and 75 days for Phase 2) during two construction seasons from April 1, 2020 through March 31, 2022, with construction occurring primarily from April through November of each year.

Pile installation will occur in water depths that range from a few feet or dry conditions nearest the shore to approximately 80 feet at the outer face of the loading platform, depending on tidal stage; diurnal tide range is approximately 29 feet (Figure 1-3, Figure 1-4). Figure 1-3 and Figure 1-4 show three test piles that were installed in 2016 and then removed in 2019. These test piles were located just water-ward of the face of the PCT loading platform. The PCT will be constructed between these three test piles and the shore; for illustrative purposes, the distance from the water-ward edge of the PCT loading platform (general location of previous test piles) is approximately 30m from MLLW and 115m from MHHW.

A summary of PCT activities and components is shown in Table 1-1.

Basic components of PCT Phase 1 construction include 45 48 inch piles for the loading platform, 26 48-inch piles for the access trestle, 26 36-inch and 36 24-inch temporary piles for construction of the temporary work trestle, 36 24-inch temporary piles for the access trestle template, 4 36-inch temporary piles to secure the derrick barge during construction, and 9 24-inch temporary piles for three temporary dolphins to moor vessels during construction. This equates to 71 permanent 48-inch piles for the loading platform and access trestle, and 81 temporary 24-inch and 36-inch for the temporary construction work trestle, temporary templates, and temporary mooring piles for a total of 182 piles. Construction of Phase 1 is estimated to occur over 127 days of in-water construction and involve an estimated 359 total hours of pile installation and removal (see Table 1-2).

Phase 1 construction mobilization is scheduled to commence the first week of April 2020, with in-water pile driving initiating mid-April. Construction demobilization is planned to occur in November 2020 with the expectation to remove the final temporary piles by the first week of November. Between April and November, piles will be installed and removed during daylight hours only. The project is sequentially staged; therefore, it is unlikely pile installation would be evenly distributed throughout the construction season. The POA has committed to strive to install as many piles as possible early in the season when marine mammal abundance, particularly of the endangered Cook Inlet beluga whale, is low and to perform out-of-water work (e.g., deck work) during periods when beluga whale abundance is high (e.g., August). However, it is not practicable for the POA to commit to a certain schedule given the short season, contractor scheduling, and unforeseen delays.

Basic components of PCT Phase 2 construction include 9 144-inch monopile dolphins (6 mooring and 3 breasting), 72 36-inch temporary template piles, 4 36-inch temporary piles to secure the derrick barge during construction, and 9 24-inch temporary piles for three temporary dolphins to moor vessels during construction. This equates to 9 permanent 144-inch monopiles and 85 24-inch and 36-inch temporary template and temporary mooring piles for a total of 94 piles. Construction of Phase 2 is estimated to occur over 75 days of in-water construction and involve an estimated 229 total hours of pile installation and removal (see Table 1-2).

Phase 2 construction mobilization is scheduled to commence in April 2021, with in-water pile driving initiating in May. Construction demobilization is planned to occur in November 2021 with the expectation to remove the final temporary piles in early November. The project is sequentially staged; therefore, it is unlikely pile installation would be evenly distributed throughout the construction season. However, there will be several days of no pile driving while the pile segments of the 144-inch piles are being spliced and out-of-water work is occurring. The POA will encourage the construction contractor to install as many piles as possible early in the season when beluga whale abundance is low, and to perform out-of-water work (e.g., deck work) during periods when beluga whale abundance is high (e.g., August). However, it is not practicable for the POA to commit to a certain schedule given the short season, contractor scheduling, and unforeseen delays.

Overall for both Phase 1 and Phase 2, in-water construction is estimated to occur over 202 total construction days involving 276 permanent and temporary piles installed/removed for an estimated 588 total hours.

A bubble curtain will be deployed to reduce in-water sound levels during PCT construction for impact and vibratory hammer pile installation of 144-, 48-, 36-, and 24-inch plumb (vertical) piles and vibratory hammer removal of 36- and 24-inch plumb piles (all temporary and permanent piles). A bubble curtain will not be deployed during installation and removal of 24-inch battered (installed at an angle, not vertical) piles for the temporary construction work trestle and temporary dolphins due to the difficult geometric application.

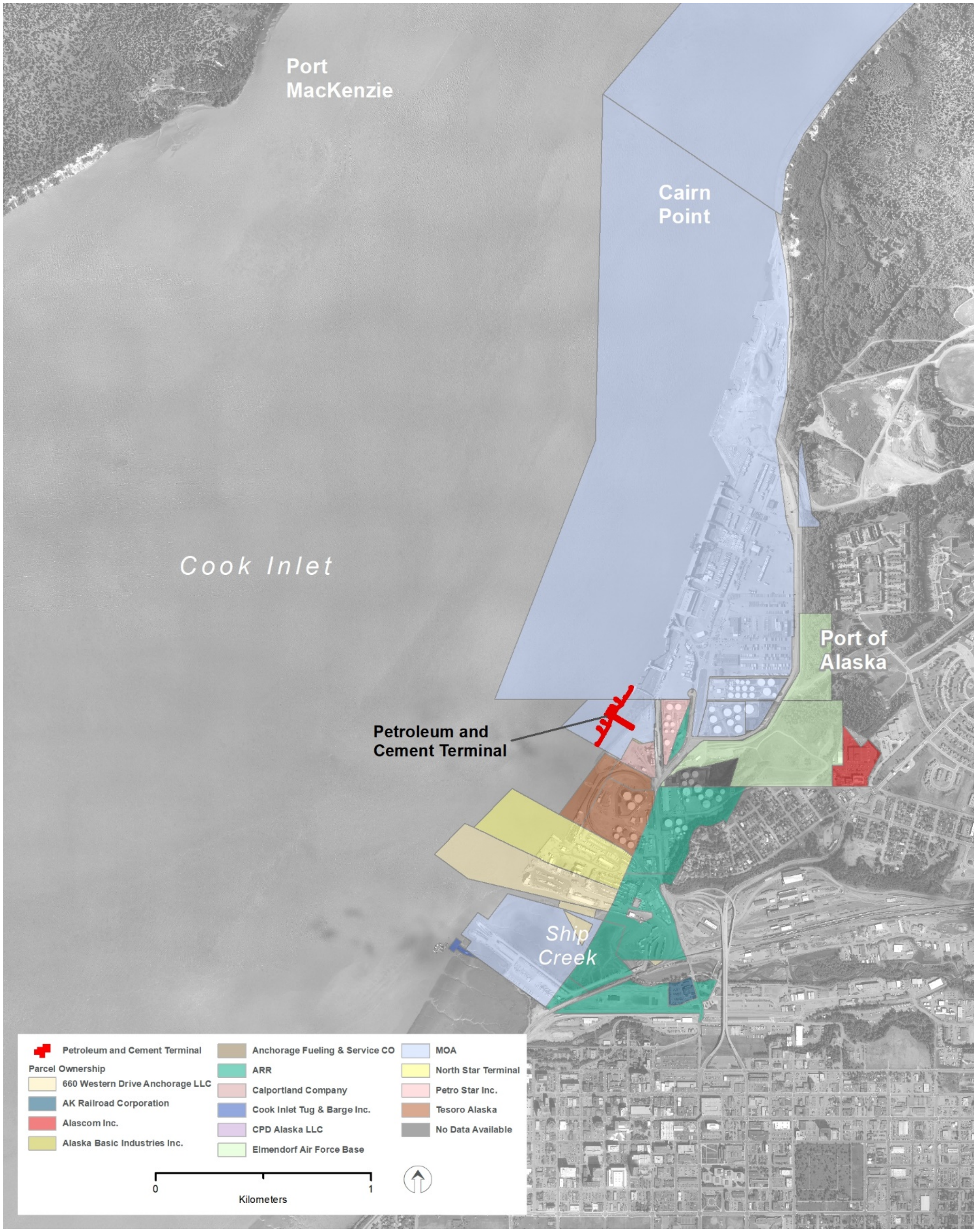

Figure 1-1. Location of the Proposed PCT in Knik Arm

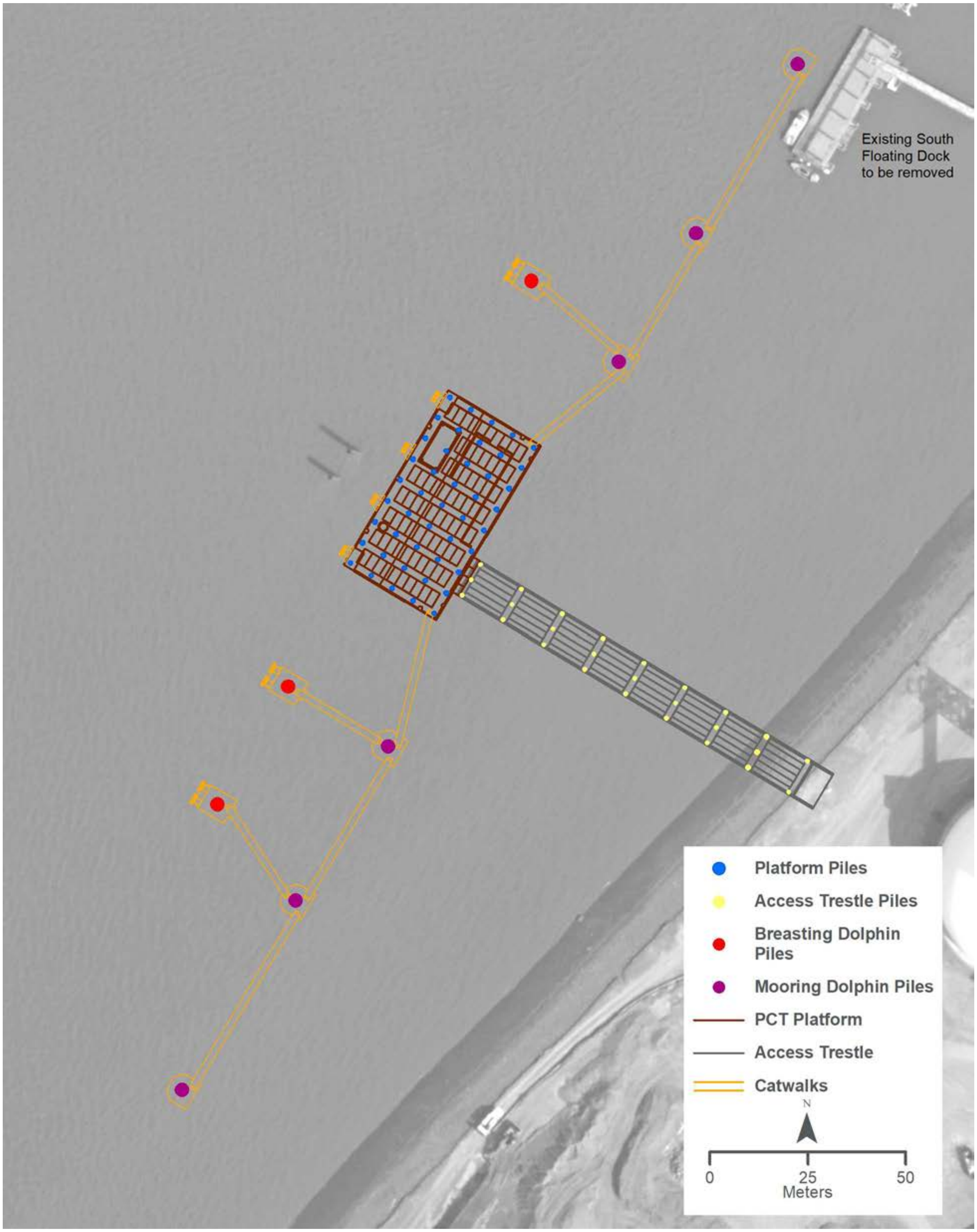

Figure 1-2. Project Footprint and Pile Locations of the Proposed PCT

Figure 1-3. Preparation of the Shoreline for the Proposed PCT Access Trestle. The Three Test Piles Visible in the Photo are Located Offshore of the Face of the Proposed PCT Loading Platform (Test piles removed in 2019)

(Note that the temporary fill pad shown in photo is part of 2018 construction work to stabilize near-shore soils and was removed following the 2018 construction season.)

Figure 1-4. Cross-sectional View of the PCT Installation Site at Low Tide (Including Side View of Temporary Fill Pad)

Table 1-1. Summary of PCT Project Components and Activities

Type of Activity	Location	Phase	Size and Type	Total Amount or Number
Permanent Components				
Permanent pile installation (loading platform)	In water	1	48-inch steel pipe (plumb)	45 piles
Permanent pile installation (access trestle)	In water	1	48-inch steel pipe (plumb)	26 piles
Permanent pile installation (breasting and mooring dolphins)	In water	2	144-inch steel pipe (plumb)	9 piles
Installation of concrete decking on loading platform and main trestle	Above water	1	Pre-cast panels	About 120 panels
Catwalks	Above water	2	Prefabricated steel or aluminum trusses with open steel grating	9 units, totaling 990 feet
Construction Support and Temporary Components				
Vessel support	In water	1 & 2	Barges and tugs	16 flat deck barges, 2 derrick barges, and 3-4 tugs
Temporary pile installation (construction work trestle)	In-water	1 1	24-inch steel pipe (plumb) 24-inch steel pipe (battered)	26 piles 10 piles
Temporary pile installation (dolphin templates)	In-water	2	36-inch steel pipe (plumb)	72 piles
Temporary pile installation (construction work trestle)	In-water	1	36-inch steel pipe (plumb)	26 piles
Temporary pile installation (access trestle templates)	In-water	1	24-inch steel pipe (plumb)	36 piles
Temporary mooring anchor systems	In-water	1 & 2	20,000 pound Danforth anchors	2 mooring systems
Temporary derrick barge mooring	In-water	1 & 2	36-inch steel pipe (plumb)	4 piles
Temporary dolphins for mooring construction vessels	In-water	1 & 2	24-inch steel pipe (plumb) 24-inch steel pipe (battered)	3 dolphins, each with 1 plumb and 2 battered piles (9 piles total)
Installation of Utility, Petroleum, and Cement Lines				
Installation on access trestle and loading platform	Above water, on-dock	1	Pipelines, various sizes and types	300–600 linear feet each

1.3.1 PCT Permanent Construction

It is important to note that PCT construction activities and components may change as the design is revised, construction contracts are awarded, and construction details are further refined. The following information is currently the best estimate for PCT design and construction elements.

The loading platform will be supported by approximately 45 round, 48-inch-diameter steel pipe piles (Table 1-2) and will have a plan surface area of 15,300 square feet. The loading platform will connect to the shore by the access trestle, which will be supported by 26 round, 48-inch-diameter steel pipe piles and have a plan surface area of approximately 11,254 square feet. Six mooring dolphins and three breasting dolphins will each consist of a single round, 144-inch-diameter steel pipe pile. Catwalks will be installed above the water to connect the dolphins and loading platform.

An APE D180 diesel impact hammer or equivalent will likely be used to install the 36- and 48-inch piles. A Menck 800S hydraulic impact hammer or equivalent will likely be used to install the 144-inch monopile dolphins. The numbers of strikes required to install each pile size and type were determined using a Wave Equation Analysis of Pile Driving (WEAP), a commonly used modeling approach that predicts the relationship between pile capacity, blow counts and pile-driving stress. An APE 600 or similar vibratory hammer may be used, if necessary, on approximately 10 percent (estimate) of the 48- and 144-inch piles for safety reasons or if a pile encounters an obstruction or a constructability condition occurs, and extraction or adjustment is required.

The POA expects to utilize three hammers on the job site to expedite construction, including an impact hammer for loading platform construction and an impact and vibratory hammer for permanent and temporary work trestle construction. In order to mitigate potential impacts to beluga whales and attempt to maximize pile installation activities during the lower abundance months of occurrence (April-July), the contractor plans to add a third crane with a vibratory hammer to the equipment work mix in order to accelerate construction of the temporary and permanent trestles. This could mean that one vibratory and one impact hammer may be operating at the same time (simultaneously) along the trestles for brief periods of time. Use of these hammers could also be coincidental with use of the impact hammer installing the loading platform piles. It is not anticipated that two vibratory hammers will be operating at the same time.

Given the proximity of the platform and trestle, hammers could work in very close range to each other or as far as 100 m away from each other. The most likely combinations of piles that could be installed within a day include (1) vibratory hammer installation of 24-inch temporary piles and impact hammer installation of 48-inch permanent trestle or loading platform piles, and (2) vibratory hammer installation of 36-inch temporary piles and impact hammer installation of 48-inch permanent trestle or loading platform piles. When using two hammers, one must consider the accumulated energy and there are fundamental approaches for adjusting source levels to account for the aforementioned scenarios. While two impact hammers could work at the same time, it is unlikely the hammers would be dropping at the exact same time; therefore, two impact hammers would not necessitate an adjustment. Assessment of sound levels associated with use of two hammers within a day is presented in Section 6.3.2.3.

Use of two hammers within a day will increase the production rate on those days, thereby reducing the number of days of work required to complete the project and reducing the overall duration of the project construction. This would reduce the number of marine mammals potentially exposed to Level B harassment, which is calculated based on the number of days of pile installation and removal. Two hammers may operate simultaneously for brief periods of time within a day.

Data collected during the PAMP 2016 Test Pile Program (TPP) indicated that a bubble curtain was an effective sound attenuation device (Section 6.3.2). A bubble curtain will be deployed to reduce in-water sound levels during PCT construction for impact and vibratory hammer pile installation of 144-, 48-, 36-, and 24-inch plumb (vertical) piles and vibratory hammer removal of 36- and 24-inch plumb piles (all temporary and permanent piles). A bubble curtain will not be deployed during installation and removal of 24-inch battered (installed at an angle, not vertical) piles for the temporary construction work trestle due to the difficult geometric application.

1.3.1.1 Loading Platform and Access Trestle – Phase 1

Construction of the loading platform and access trestle will occur during Phase 1. The access trestle is comprised of eight bents (clusters) of three piles each and one bent of two piles at the abutment. Loading platform and access trestle 48-inch piles will be installed using an impact hammer for approximately 92 and 120 minutes per pile, respectively (Table 1-2), with an average strike rate of 25 strikes per minute. Loading platform and access trestle piles will be driven through the overburden sediment layer and into the bearing layer, to an average embedded depth of about 100 feet (loading platform piles) and 130 feet (access trestle piles) below the substrate. It is estimated that one or two loading platform or trestle piles will be installed per day; three or more piles may be installed on some days. Anticipating an average production rate of 1.5 piles per day, installation of loading platform and trestle piles will require about 47 intermittent days of effort (71 loading platform and trestle piles/1.5 loading platform and trestle piles per day = 47 days; Table 1-2). Vibratory hammer methods may be used to install loading platform and trestle piles if necessary for constructability or safety reasons, or if a pile encounters an obstruction or constructability issue. It is anticipated that 30 minutes of vibratory hammer application per pile may be necessary on approximately 10 percent of loading platform and access trestle piles, or approximately 7 piles.

Table 1-2. PCT Construction Pile Details and Estimated Effort Required for Pile Installation and Removal

Pipe Pile Diameter	Structural Feature[a]	Number of Piles	Total Number of Piles	Average Embedded Depth (feet)	Vibratory Duration Per Pile (minutes)[b]	Impact Strikes Per Pile	Estimated Total Number of Hours[c]	Production Rate Piles per Day (Range)	Days of Installation and Removal[d]
Phase 1									
48-inch	Loading Platform	45	71	100	30 minutes: 10% (7 piles):	2,300 50 restrikes each for 4 piles	73	1.5 (1-3)	30
	Access Trestle	26		130		3,000 50 restrikes each for 3 piles	56		17
36-inch	Temporary Construction Work Trestle	26	30	115	75	50 restrikes for 10 piles	33	3 (2-4)	9 installation 9 removal
	Temporary Derrick Barge Mooring	4		40	75	NA	5	4	1 installation 1 removal
24-inch	Temporary Construction Work Trestle	26	81	140	75	50 restrikes for 10 piles	65	3 (2-4)	9 installation 9 removal
	Temporary Construction Work Trestle, Battered	10		105	75	NA	25	1.6 (1-2)	6 installation 6 removal
	Temporary Construction Access Trestle Template	36		105	75	NA	90	3 (2-4)	12 installation 12 removal
	Temporary Dolphins for mooring construction vessels	3		50	30	NA	3	3	1 installation 1 removal
	Temporary Dolphins for mooring construction vessels, Battered	6		50	30	NA	9	3	2 installation 2 removal
Phase 1 Construction Totals			**182 piles**				**359**		**127**

Table 1-2. PCT Construction Pile Details and Estimated Effort Required for Pile Installation and Removal

Pipe Pile Diameter	Structural Feature[a]	Number of Piles	Total Number of Piles	Average Embedded Depth (feet)	Vibratory Duration Per Pile (minutes)[b]	Impact Strikes Per Pile	Estimated Total Number of Hours[c]	Production Rate Piles per Day (Range)	Days of Installation and Removal[d]
Phase 2									
24-inch	Temporary Dolphins for mooring construction vessels	3	9	50	30	NA	3	3	1 installation 1 removal
	Temporary Dolphins for mooring construction vessels, Battered	6		50	30	NA	9	3	2 installation 2 removal
36-inch	Temporary Construction Dolphin Template	72	76	115	75	NA	180	3 (2-4)	24 installation 24 removal
	Temporary Derrick Barge	4		40	75	NA	5	4	1 installation 1 removal
144-inch	Mooring Dolphin	6	9	140	45 minutes: 10% (1 pile)	5,000 (1,500 first day, 3,500 second day)	21	0.5 (0.3 or 0.7)	13
	Breasting Dolphin	3		135			11		6
Phase 2 Construction Totals			**94 piles**				**229**		**75**
PCT Construction Totals[e]			**276 piles**				**588 hours**		**202 days of installation and removal**

[a] Piles are plumb (vertical) unless battered is specified.

[b] It is estimated that 10% of 144-inch and 48-inch piles will require some vibratory hammer installation.

[c] Hours are estimated for impact and vibratory hammer installation and vibratory removal combined, using a strike rate of 25 strikes/minute for impact hammering.

[d] The average production rate was estimated based on the estimated number of non-consecutive days of installation and removal. Days are used in Section 6 to calculate exposure estimates.

[e] Discrepancies in addition are due to rounding.

Note: Durations are estimated and may vary based on the Contractor's means and methods. PCT = Petroleum and Cement Terminal.

1.3.1.2 Mooring Dolphins – Phase 2

Six mooring dolphins will be constructed parallel to and landward of the loading platform face during Phase 2 (Figure 1-2). These dolphins will provide additional secure mooring points for ships docking at the terminal. Each mooring dolphin will be comprised of a single round, 144-inch-diameter steel pipe pile, driven to an average embedded depth of about 140 feet below the substrate (Table 1-2). Piles will be installed using an impact hammer for approximately 200 minutes per pile, divided between 2 non-consecutive days. About 60 minutes of impact installation (30 percent of the total effort) will be required the first day to install the first pile segment. It is anticipated that several days will be required to splice the second segment and prepare it for installation. The second day of impact installation will require about 140 minutes (70 percent of the effort). Anticipating an average production rate of 2 days per pile, installation of mooring dolphin piles will require about 12 intermittent days of impact pile installation effort (6 mooring dolphin piles * 2 days/pile = 12 days; Table 1-2). Vibratory hammer application may be used on the 144-inch mooring or breasting dolphin piles if necessary for safety reasons or if a pile encounters an obstruction, potentially adding an additional day of in-water pile installation (Table 1-2). It is anticipated that 45 minutes of vibratory hammer application may be necessary on approximately 10 percent (estimate) of mooring or breasting dolphin piles, or approximately 1 pile, for 1 day if extraction or adjustment is required. This sums to 13 days (12 days of impact installation, one day of vibratory installation) of potential in-water pile installation for dolphin monopiles.

1.3.1.3 Breasting Dolphins – Phase 2

Three breasting dolphins will be constructed parallel with the PCT loading platform face during Phase 2 (one dolphin north of the loading platform and two to the south; Figure 1-2). Each of the breasting dolphins will be comprised of a single round, 144-inch-diameter steel pipe pile, driven to an average depth of about 135 feet below the substrate (Table 1-2). Similar to the mooring dolphins, installation of each pile for the breasting dolphins is estimated to require approximately 200 minutes per pile, divided between 2 non-consecutive days, with effort split at 30 percent the first day and 70 percent the second day. Anticipating an average production rate of 2 intermittent days per pile, installation of breasting dolphin piles will require about 6 intermittent days of effort (3 breasting dolphin piles * 2 days/pile = 6 days; Table 1-2).

1.3.2 PCT Temporary Construction

1.3.2.1 Temporary Construction Work Trestle – Phase 1

A temporary construction work trestle is anticipated to be necessary to support construction of the access trestle during Phase 1 and will be located adjacent, parallel to, and north of the access trestle (Figure 1-5). It is anticipated that approximately 26 36-inch diameter steel pipe piles installed plumb, 26 24-inch-diameter steel pipe piles installed plumb, and 10 24-inch-diameter pipe piles installed at an angle (battered) will be required to create this temporary structure. The piles will be installed approximately 105 feet into the substrate (Table 1-2). Temporary piles are required to be installed using a vibratory hammer due to specific construction requirements, accuracy, sequencing, and schedule. Restrikes or proofing of 36- and 24-inch-diameter temporary trestle piles are anticipated to be required and will consist of 50 blows per pile over an estimated 10 minute timeframe for each pile. Proofing involves brief periods of restrikes while instrumentation is attached to the pile to confirm adequacy for handling construction equipment loads. Approximately 10 each of the 36- and 24-inch temporary trestle piles are estimated to require restrikes to confirm adequate loads for construction equipment. Restrikes of 36- and 24-inch piles will occur concurrent with other pile installation activities and will not add additional days of work to the project timeline. Installation of the 26 36-inch-diameter plumb piles will take approximately 9 days at a rate of 2 to 4 piles per day (26 temporary work trestle piles/3 piles per day = 9 days). Installation of the 26 24-inch-diameter plumb piles will take approximately 9 days at a rate of 2 to 4 piles per day (26 temporary work trestle piles/3 piles per day = 9 days). Installation of the 10 24-inch-diameter battered piles will take approximately 6 days at a rate of 1 to 2 piles per day (10 temporary work trestle piles/~1.6 piles per day = 6 days). Removal is expected to require the same number of days as installation (9 days, 9 days, and 6 days) due to the strong pile set up and resistance conditions related to Knik Arm soils. Therefore, installation and removal of 62 piles to support the temporary construction work trestle is anticipated to occur over approximately 48 days.

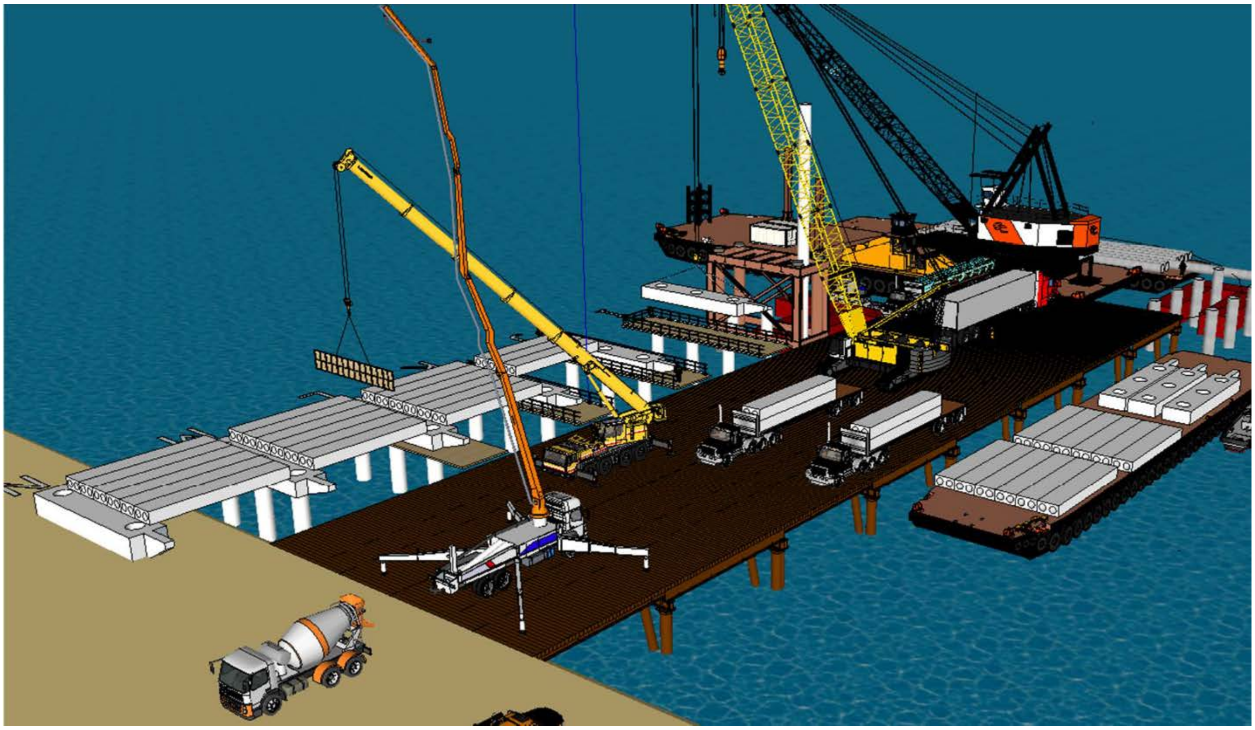

Figure 1-5. Stylized Illustration of a Typical Temporary Construction Work Trestle

1.3.2.2 Temporary Construction Access Trestle Template – Phase 1

A driving template supported by 4 24-inch piles will be required during Phase 1 for construction of each of the 9 bents of the access trestle (9 bents * 4 piles per driving template = 36 total temporary access trestle template piles). This template will also be used as a welding platform during splicing operations. Temporary construction template piles will be installed with a vibratory hammer due to accuracy requirements for setting the template. Anticipating an average production rate of 3 piles per day, installation of temporary access trestle template piles will require about 12 days of effort (36 temporary access trestle template piles/3 piles per day = 12 days; Table 1-2). Removal is expected to require the same number of days as installation due to the strong pile set up and resistance conditions related to Knik Arm soils. Therefore, installation and removal of 36 piles to support the temporary construction access trestle template is anticipated to occur over approximately 24 days (Table 1-2).

1.3.2.3 Temporary Barge Mooring – Phase 1 and 2

A temporary derrick barge mooring will be installed adjacent to the loading platform during Phase 1 and near the dolphins during Phase 2 to secure the derrick barge during construction. The mooring will be comprised of four 36-inch-diameter steel pipe piles and will be installed with a vibratory hammer to hold the barge in position. Installation of the four temporary barge piles will require 1 day of effort, and vibratory hammer removal will require an additional day (Table 1-2).

1.3.2.4 Temporary Dolphins – Phase 1 and 2

Three temporary breasting dolphins will be installed near the PCT during Phase 1 and Phase 2. Working barges associated with the PCT Project will use the temporary breasting dolphins during PCT construction. Each temporary dolphin will consist of one 24-inch plumb piles and two 24-inch battered pile installed with a vibratory hammer. Anticipating an average production rate of 3 piles per day, installation of temporary dolphin piles will require 3 days of effort (3 temporary dolphins * 3 piles = 9 piles/3 piles/day = 3 days of installation). Vibratory hammer removal will require an additional 3 days (Table 1-2).

1.3.2.5 Temporary Construction Dolphin Template – Phase 2

Temporary construction piles will be needed to anchor the template that will guide the installation of 144-inch piles at each of the nine dolphin locations during Phase 2 (Figure 1-6). It is anticipated that temporary construction piles to support the dolphin template will be 36-inch-diameter steel pipe installed 115 feet into the substrate (Table 1-2). Eight temporary construction piles will be needed for each mooring and breasting dolphin, for a total of 72 temporary construction piles. All 72 piles will be aligned plumb (vertically) and installed and removed using a vibratory hammer due to accuracy requirements for setting the template. Installation and removal of the 8 temporary piles to support each template will likely occur over 6 days at each location (3 days for installation and 3 days for removal). Additional time will be required for setup of the template structure, which will include welding, surveying the location, and other activities. Each temporary pile will be installed in approximately 75 minutes and removed in approximately 75 minutes. Approximately 3 temporary piles are estimated to be installed or removed per day, for a total of up to 225 minutes of vibratory hammer installation or removal per day. Installation of temporary piles for the dolphin template will require about 24 days of effort and removal will require 24 days of effort (72 temporary piles/3 temporary piles per day = 24 days each for installation and removal).

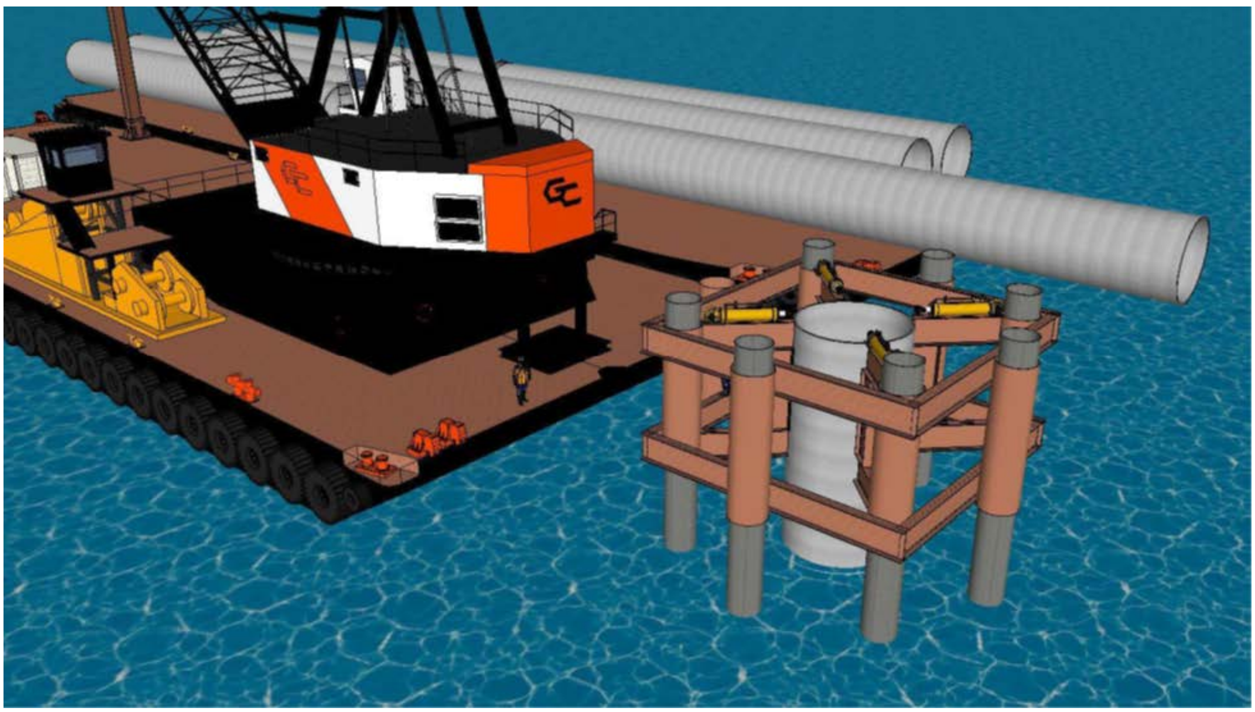

Figure 1-6. Stylized Illustration of a Typical Dolphin Pile Template

1.3.2.6 Platform and Access Trestle Construction Description– Phase 1

Construction of the PCT in Phase 1 will be accomplished through two concurrent headings or work approaches; one marine-side derrick barge with a crane/hammer will be used to construct the loading platform and a land-side crawler crane/hammer will be used to construct the temporary and permanent access trestle from the shoreline out. The crawler crane will initially advance the temporary work trestle out from the shoreline with a top-down or leap-frog type construction method, and then the crawler crane will work off of the temporary work trestle to construct the permanent trestle all the way out to the loading platform.

For the loading platform, the contractor will first mobilize the marine-based derrick barge on the seaward side of the platform location and install four temporary 36-inch mooring piles to stabilize the derrick barge during the construction season. Also, three temporary mooring dolphins will be constructed in the vicinity of the PCT to serve as mooring for construction vessels and barges containing construction materials; these will be removed at the end of the construction season. The derrick barge will host the crane and hammer used to install the loading platform piles and decking. Each of the permanent platform piles will be installed using an impact hammer with a bubble curtain applied. A vibratory hammer would only be used on the permanent platform piles in the infrequent event that an obstruction, safety or constructability condition is encountered while driving the pile that requires removal or repositioning of the pile with a vibratory hammer.

Four of the permanent platform piles will be “proofed” to confirm their ability to withstand design loads. Proofing involves approximately 50 impact hammer restrikes over an approximate 10 minute period while instrumentation is attached to the pile during restrike to confirm design conformance. Pile cleanout activities, to prepare the interior of the hollow pile for partial concrete filling, will occur only in the top portion of the pile, but not below mudline. Any material adhered to the top inside of the pile will be removed to prepare for concrete installation, and a soffit form will be inserted into the hollow pile to prevent the closure pour concrete from reaching mudline. Formwork will be constructed around the top of the pile, out of the water, to support placement of a precast concrete cap atop each pile. The closure pour, where concrete is poured into the pile above the soffit form, connects the pile to the precast pile caps, bonding the pile to the cap. Precast platform panels are then placed on the deck, and additional concrete will be poured on top of the panels to create the platform decking.

The permanent access trestle construction will require construction of a parallel temporary work trestle, installed adjacent to the permanent trestle, which will be used to advance the temporary piles used for the trestle templates and installation of the permanent access trestle piles. Initial construction of the temporary work trestle will be advanced first and then as the work trestle advances water-ward and room is made available to accommodate construction equipment, work will commence on construction of the permanent access trestle coincidentally as the temporary work trestle is advanced water-ward towards the loading platform. Construction of the trestles will occur concurrently with construction of the loading platform. A crawler crane will be used to install piles for the temporary trestle, building seaward from the shore in a top-down or leap frog construction method. The crawler crane will advance onto the temporary trestle to complete pile installation and decking for the temporary trestle. Once the first section of temporary trestle is constructed and the crawler crane advanced, a second crawler crane will advance on to the deck of the temporary trestle and be used to install the first section of template and permanent piles for the permanent access trestle.

Three of the permanent trestle piles will be “proofed” to confirm their ability to withstand design loads. In addition, it is estimated that 10 each of the 24-inch and 36-inch temporary work trestle piles may need to be proofed to confirm load capacities for construction equipment. Template piles will stay in place until precast pile caps are placed on the permanent trestle piles following installation. The temporary work trestle will stay in place for the entire construction season, and will be used as a work platform for decking installation on the permanent trestle. The temporary work trestle decking and piles will be removed at the end of construction activities for Phase 1.

The abutment bent (two piles) is located above mean high water (MHW) on shore and will be installed in-the-dry. The next three bents are located in the intertidal zone and therefore may or may not be installed in-water depending upon tidal stage (i.e., if the tide is high, they may be in-water but if the tide is low, they will not be in-water). The parallel temporary construction trestle will follow the same pattern. For purposes of this analysis, it is assumed that all piles will be driven in water in regard to estimated take calculations, however if/when piles are driven in the dry or with very shallow water conditions, takes of marine mammals will be assumed not to occur. Also, some of the permanent trestle piles may be started/partially driven with a vibratory hammer when “in the dry” or in very shallow water conditions at the abutment (two piles) and first three bents (three piles each) in order to set the pile up for impact hammer installation; this condition also is not expected to generate takes. This is a unique situation at this location due to the highly variable tidal conditions and the need to provide initial pile support for impact hammer installation.

1.3.2.7 Mooring and Breasting Dolphins Construction Description– Phase 2

For Phase 2, construction will be accomplished from one marine-based derrick barge with a crane/hammer work station. Similar to Phase 1, the contractor will initially install four temporary 36-inch mooring piles to stabilize the derrick barge during the construction season. Also, three temporary mooring dolphins will be constructed in the vicinity of the PCT to serve as mooring for construction vessels and barges containing construction materials, and will be removed at the end of the construction season. The derrick barge will host the crane and hammer used to install the mooring and breasting dolphins. Temporary template piles will then be installed to anchor the template that will guide the installation of the permanent dolphin piles at each of the dolphin locations. Template piles will be installed approximately 115 feet into the substrate. These temporary 36-inch template piles will be driven in a grid formation surrounding the location of each dolphin pile, with a steel framework bolted to the temporary piles to guide dolphin pile installation. The framework includes adjustable components and hydraulic guides that can be adjusted to maintain correct positioning of the dolphins once in place. All template piles will be aligned plumb (vertically) and installed and removed using a vibratory hammer due to accuracy requirements for setting the template. All temporary plumb piles will employ a bubble curtain during all pile driving activity.

Six mooring dolphins will be constructed parallel to and landward of the loading platform face (Figure 1-2). These dolphins will provide secure mooring points for ships docking at the terminal. Each mooring dolphin will be comprised of a 144-inch single round steel pipe pile or monopile, driven to an average embedded depth of about 140 feet below the substrate. Following temporary pile installation with a vibratory hammer for the dolphin template, held in place with 36-inch piles, the crane will loft the first permanent pile length (approximately 100 feet) and ready it for lowering through the template framework. The crane will have a boom holding the top of the pile as well as a spotter arm lower on the pile to steady the pile for positioning. The pile will then be lowered through the template and readied for pile driving. Impact pile driving will be used to advance the pile to a prescribed depth, at which point pile driving activity will stop to allow field splicing of the second pile length. Decking will be added to the temporary pile template framework to accommodate welders; no pile driving will be conducted during welding and testing the two lengths of pile, as the crane will be holding the second pile length in place. Once the first and second lengths of pile are spliced, pile driving will be reinitiated until the tip is at the prescribed depth. Limited vibratory hammer application may be required on the mooring or breasting dolphin piles for safety or constructability reasons, or if a pile encounters an obstruction.

Following monopile installation, the superstructure will be installed on top of the monopile. A precast concrete mooring cap will be added to the monopile. The caps will be welded to the piles by an embedded steel ring in the precast cap. This activity will not require in-water work or hammer activity. The three breasting dolphins will have fenders installed, which will be attached to the mooring cap and will not require in-water or hammer work.

Once the first and second lengths of pile, ring and mooring cap, and fender, if applicable, are assembled at the first location, the temporary template piles will be removed using a vibratory hammer. The barge will then be repositioned to the next location, and the work activity will commence as described above.

One crane and hammer will be used for installation of dolphin piles and associated temporary template piles; multiple hammers will not be employed simultaneously. Templates will be re-used at each dolphin location. The crane will alternate between installing template piles, driving dolphin pile, removing template piles, and out-of-water work such as placement of decking, catwalks, and utility racks along the platform and trestle. All terminal utility work is out of the water, and includes installation of pipe racks and utilities along the platform and trestle.

1.3.3 Other Construction Activities

1.3.3.1 Temporary Mooring Anchor Systems

Two temporary mooring anchor systems will be installed and utilized throughout both phases of PCT construction. The anchor systems will provide mooring for construction barges at a location that is slightly removed from the immediate work area, which will minimize congestion and facilitate vessel movements. Each anchor system is comprised of an approximately 20,000-pound Danforth anchor connected to a chain and buoy. No pile installation or removal is associated with these structures. No elevated in-water sound levels are anticipated from the installation and use of mooring anchor systems.

1.3.3.2 Installation of Utility Lines and Pipelines

Utility lines will include water, electric, and communication lines. New pipelines will be installed to carry petroleum and cement. Utility, petroleum, and cement lines will extend between the PCT loading platform and the shore, and will connect with existing onshore infrastructure. The installed utility lines and pipelines will be supported by the access trestle and loading platform above marine waters. No pile installation or removal is associated with these auxiliary activities; therefore, no impacts on the aquatic environment, including elevated in-water noise, are anticipated from the installation of utility lines and pipelines.

1.3.4 Construction Support

During construction of the PCT, the Contractor is expected to mobilize cranes, tugs, and floating barges, including two 300-ton derrick barges, each with a mounted crane. Barges will be moved into location with tugboats. Approximately three to four tugboats and approximately 6 barges may be onsite at one time. Cranes will be used to conduct overwater work from barges, which are anticipated to remain on-site for the duration of the PCT construction period.

1.3.5 Noise Mitigation

A confined air bubble curtain noise attenuation system was tested during the PAMP 2016 TPP, and was found to be an effective method of reducing in-water propagation of sound pressure levels from impact and vibratory installation of 48-inch vertical steel pipe piles (Section 6.3.2). During the PCT Project, an air bubble curtain noise attenuation system (bubble curtain) will be used during installation and removal of plumb (vertical) piles of all sizes, as feasible. A bubble curtain will not be used on battered piles (piles installed at an angle) due to the geometry of the template. It may not be possible to use a bubble curtain on piles installed or removed in shallow water or piles installed or removed “in the dry,” (e.g., at times when the tide is low and the installation location is dewatered [Figure 1-3 and Figure 1-4]). The tides at the POA have a mean range of about 8.0 meters (26 feet; NOAA 2015), and low water levels will prevent proper deployment and function of the bubble curtain system. When a pile is installed or removed in the dry, it will be assumed that no exposure occurs to noise that is defined as Level B harassment, and no take occurs of marine mammals. When the water is too shallow for deployment of a bubble curtain, the harassment zones for unattenuated impact pile installation will be monitored (see Section 6.4).

It is assumed for the PCT Project that a well-designed and robust bubble curtain system will achieve a mean reduction of 7 dB near the source and 7 dB away from the source (i.e., beyond 500 meters; U.S. Navy 2015) for both impact pile installation and vibratory pile installation and removal (see Section 6.3.2.2).

A bubble curtain reduces the propagation of noise through the water by inhibiting transmission of noise through the air bubble-water interfaces. As a pile is installed or removed, air is released into the bubble curtain system through a series of vertically distributed bubble rings made from pipes that surround the pile. A bubble curtain system can also be designed to surround a set of piles. A series of compressors provides a continuous supply of compressed air, which is distributed among the layered bubble rings. Air is released from small holes in the bubble rings to create a curtain of air bubbles surrounding the pile. The curtain of air bubbles floating to the surface inhibits the transmission of pile installation noise into the surrounding water column. As the bubbles float to the surface and expand, new bubbles are released from the layers of rings, providing a range of bubble sizes at every depth that effectively attenuate different sound frequencies. The final design of the bubble curtain used during the PCT Project will be determined by the construction contractor based on factors such as water depth, current velocities, and pile size (Section 11).

1.4 Applicable Permits and Authorizations

The following permits and authorizations are applicable to in-water work addressed by this application:

- Alaska Department of Environmental Conservation Clean Water Act Section 401 Water Quality Certification
- MOA Flood Hazard Permit
- U.S. Army Corps of Engineers (USACE) Rivers and Harbors Act Section 10 permit and Section 408 permission, and Clean Water Act Section 404 Permit

2 Dates, Durations, and Geographic Region

2.1 Dates and Durations

2.1.1 Dates

The POA requests an IHA that is valid for 1 year, from 01 April 2020 through 31 March 2021, and a second IHA that is valid for a second, subsequent year, from 01 April 2021 through 31 March 2022.

2.1.2 Durations

The number of days of PCT in-water pile installation and removal is estimated at 127 days for Phase 1 and 75 days for Phase 2 (Table 1-2). Each phase is anticipated to occur between April and November of 2020 and 2021, respectively. These dates are estimates and may shift as contracting details, starting dates, production rates, and other factors vary.

2.2 Geographic Region

The following sections describe the overall geographical region of the PCT Project site, comprised of the physical, acoustical, and biological environments. Aspects of the biological environment considered include Essential Fish Habitat (EFH), fish, and invertebrates.

The MOA is located in the lower reaches of Knik Arm of upper Cook Inlet (Figure 2-1). The POA sits on the industrial waterfront of Anchorage, just south of Cairn Point and north of Ship Creek (Latitude 61° 15’ N, Longitude 149° 52’ W; Seward Meridian). Knik Arm and Turnagain Arm are the two branches of upper Cook Inlet, and Anchorage is located where the two arms join (Figure 2-1).

2.2.1 Physical Environment

Cook Inlet is a large tidal estuary that exchanges waters at its mouth with the Gulf of Alaska. The inlet is roughly 20,000 square kilometers (km^2; 7,700 square miles [mi^2]) in area, with approximately 1,350 linear kilometers (840 miles) of coastline (Rugh et al. 2000) and an average depth of approximately 100 meters (330 feet). Cook Inlet is generally divided into upper and lower regions by the East and West Forelands. Freshwater input to Cook Inlet comes from snowmelt and rivers, many of which are glacially fed and carry high sediment loads. Currents throughout Cook Inlet are strong and tidally periodic, with average velocities ranging from 3 to 6 knots (Sharma and Burrell 1970). Extensive tidal mudflats occur throughout Cook Inlet, especially in the upper reaches, and are exposed at low tides.

Cook Inlet is a seismically active region susceptible to earthquakes and has some of the highest tides in North America (NOAA 2015) that drive surface circulation. Cook Inlet contains substantial quantities of mineral resources, including coal, oil, and natural gas. During winter, sea, beach, and river ice are dominant physical forces within Cook Inlet. In upper Cook Inlet, sea ice generally forms in October to November, and continues to develop through February or March (Moore et al. 2000).

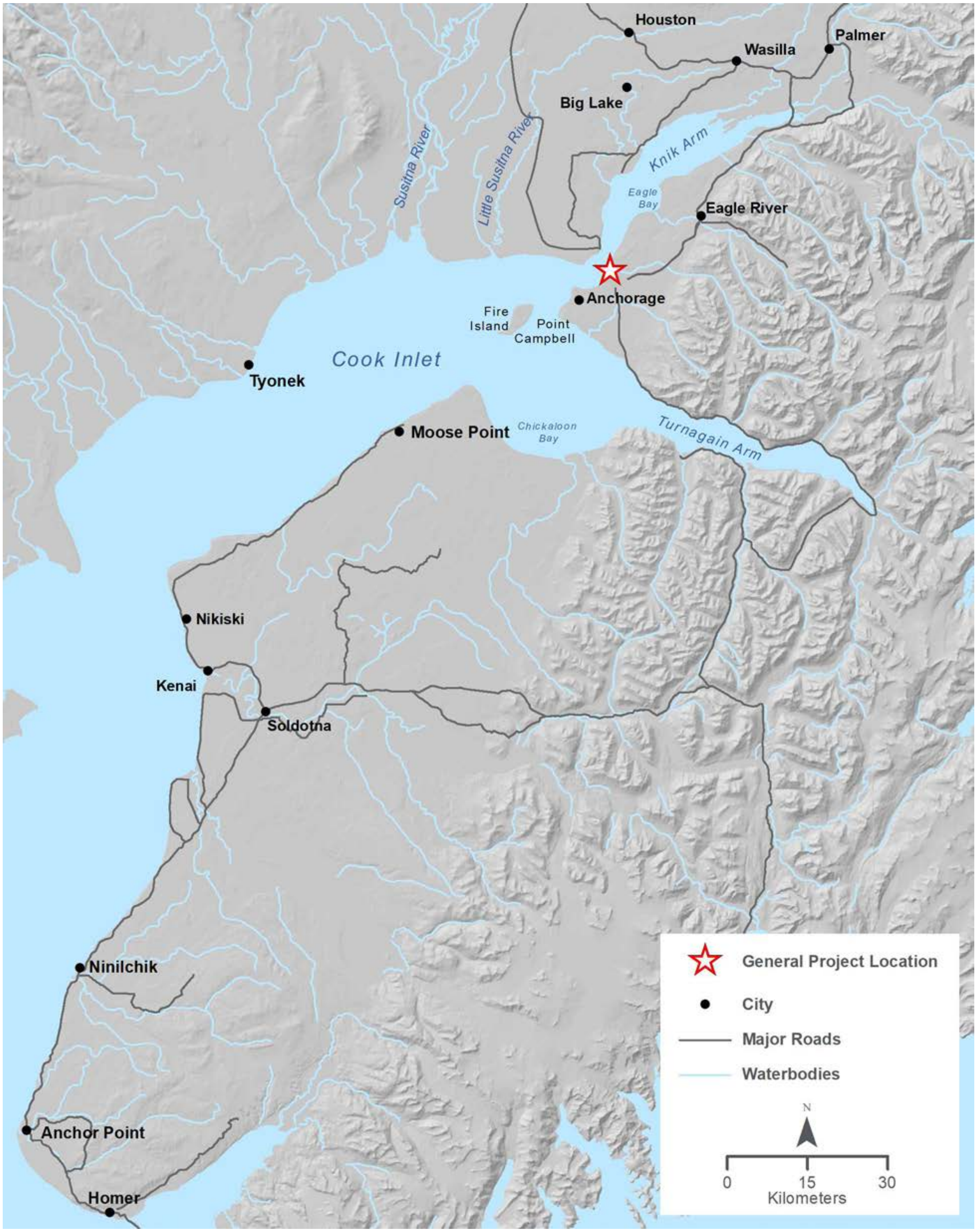

Figure 2-1. Overview of Knik Arm and Upper Cook Inlet

Northern Cook Inlet bifurcates into Knik Arm to the north and Turnagain Arm to the east (Figure 2-1). Knik Arm is generally considered to begin at Point Woronzof, 7.4 kilometers (4.6 miles) southwest of the POA. From Point Woronzof, Knik Arm extends about 48 kilometers (30 miles) in a north-northeasterly direction to the mouths of the Matanuska and Knik rivers. At Cairn Point, just northeast of the POA, Knik Arm narrows to about 2.4 kilometers (1.5 miles) before widening to as much as 8 kilometers (5 miles) at the tidal flats northwest of Eagle Bay at the mouth of Eagle River.

Knik Arm comprises narrow channels flanked by large tidal flats composed of sand, mud, or gravel, depending upon location. Approximately 60 percent of Knik Arm is exposed at mean lower low water (MLLW). The intertidal (tidally influenced) areas of Knik Arm are mudflats, both vegetated and unvegetated, which consist primarily of fine, silt-sized glacial flour. Freshwater sources often are glacially born waters, which carry high suspended sediment loads, as well as a variety of metals such as zinc, barium, mercury, and cadmium. Surface waters in Cook Inlet typically carry high silt and sediment loads, particularly during summer, making Knik Arm an extremely silty, turbid waterbody with low visibility through the water column. The Matanuska and Knik rivers contribute the majority of fresh water and suspended sediment into Knik Arm during summer. Smaller rivers and creeks also enter along the sides of Knik Arm (USDOT and POA 2008).

Tides in Cook Inlet are semidiurnal, with two unequal high and low tides per tidal day (tidal day = 24 hours, 50 minutes). Due to Knik Arm's predominantly shallow depths and narrow widths, tides near Anchorage are greater than those in the main body of Cook Inlet. The tides at the POA have a mean range of about 8.0 meters (26 feet), and the maximum water level has been measured at more than 12.5 meters (41 feet) at the Anchorage station (NOAA 2015). Maximum current speeds in Knik Arm, observed during spring ebb tide, exceed 7 knots (12 feet/second). These tides result in strong currents in alternating directions through Knik Arm and a well-mixed water column. The navigation harbor at the POA is a dredged basin in the natural tidal flat. Sediment loads in upper Cook Inlet can be high; spring thaws occur, and accompanying river discharges introduce considerable amounts of sediment into the system (Ebersole and Raad 2004). Natural sedimentation processes act to continuously infill the dredged basin each spring and summer.

The POA's boundaries currently occupy an area of approximately 129 acres. Other commercial and industrial activities related to secured maritime operations are located near the POA on Alaska Railroad Corporation (ARRC) property immediately south of the POA, on approximately 111 acres at a similar elevation. The PCT terminal footprint spans approximately 0.87 acres and is approximately 0.74 km (0.46 mile) north of Ship Creek, a location of concentrated marine mammal activity during seasonal runs of several salmon species. Ship Creek serves as an important recreational fishing resource and is stocked twice each summer. Ship Creek flows into Knik Arm through the MOA industrial area. Joint Base Elmendorf-Richardson (JBER) is located east of the POA, approximately 30.5 meters (100 feet) higher in elevation. The U.S. Army Defense Fuel Support Point-Anchorage site is located east of the POA, south of JBER, and north of ARRC property. The perpendicular distance to the west bank directly across Knik Arm from the POA is approximately 4.2 kilometers (2.6 miles). The distance from the POA (east side) to nearby Port MacKenzie (west side) is approximately 4.9 kilometers (3.0 miles).

2.2.2 Acoustical Environment

The physical characteristics of Knik Arm contribute to elevated ambient sound levels due to noise produced by winds and tides (Section 2.2.1). The lower range of broadband (10 to 10,000 Hertz [Hz]) background sound levels obtained during underwater measurements at Port MacKenzie, located across Knik Arm from the POA, ranged from 115 decibels (dB) to 133 dB referenced to 1 microPascal (dB re 1 µPa; Blackwell 2005). All underwater sound levels in this application are referenced to 1 µPa. Background sound levels measured during the 2007 test pile study for the POA's Marine Terminal Redevelopment Project (MTRP) site ranged from 105 to 135 dB (URS 2007). The ambient background sound pressure levels (SPLs) obtained in that study were highly variable, with most SPL recordings exceeding 120 dB. Background sound levels measured in 2008 at the MTRP site ranged from 120 to 150 dB (Scientific Fishery Systems, Inc. 2009). These measurements included industrial sounds from maritime operations, but ongoing USACE maintenance dredging and pile driving from construction were not underway at the time of the study.

The most recent measurements of ambient sound levels at the POA are from the PAMP 2016 TPP, when ambient sound recordings were measured at two locations during a 3-day break in pile installation. Median ambient noise levels, measured at a location just offshore of the POA South Floating Dock and at a second location about 1 kilometer offshore, were 117.0 and 122.2 dB, respectively (POA 2016a).

2.2.3 Biological Environment

2.2.3.1 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act defines EFH as “waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” The Act notes that:

> *…for the purpose of interpreting the definition of EFH, “waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities, “necessary” means the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species full life cycle.*

The North Pacific Fishery Management Council (NPFMC) identifies estuarine and marine waters in the vicinity of the POA as EFH for Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*), and pink salmon (*O. gorbuscha*) (NPFMC 2012). Marine EFH for salmon in Alaska includes all estuarine and marine areas utilized by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. Exclusive Economic Zone (NPFMC 2016).

Eulachon (*Thaleichthys pacificus*), longfin smelt (*Spirinchus thaleichthys*), and low numbers of Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasii*), and Pacific staghorn (*Leptocottus armatusspecies*) have also recently been captured in upper Cook Inlet (NOAA 2016; Houghton et al. 2005). While these species are managed by the fishery management plan for groundfish in the Gulf of Alaska, waters in the vicinity of the POA are not identified as EFH for these species (NPFMC 2016; Eagleton 2016). In addition, streams, lakes, ponds, wetlands, and other water bodies that support Pacific salmon, as identified by the Alaska Department of Fish and Game (ADF&G) *Anadromous Waters Catalog* (AWC; Johnson and Blossom 2018), are considered freshwater EFH for Pacific salmon. Details of EFH and the life stages of these species can be found in the *Anchorage Port Modernization Program Essential Fish Habitat Technical Memorandum – APMP Petroleum and Cement Terminal Project* (POA 2017a) that will be submitted to the USACE as part of the Section 10/404 permit application.

2.2.3.2 Fish

All fish species in Knik Arm are important to the diets of marine mammals, and many are important to recreational sport fishing as catch or prey. The seasonal fish resources in upper Cook Inlet are generally characterized by the spring to fall availability of migratory eulachon, out-migrating salmon smolt, and returning adult salmon, with variable species abundance and distribution throughout the summer (Moore et al. 2000). Survey data indicate that Knik Arm, including in the vicinity of the POA, provides migration, rearing, and foraging habitat to a wide diversity of marine and anadromous fish (FHWA and DOT&PF 1983; Houghton et al. 2005). NMFS determined that Chinook, sockeye, chum, and coho salmon; Pacific eulachon; Pacific cod; walleye pollock; saffron cod (*Eleginus gracilis*); and yellowfin sole (*Limanda* *aspera*) are primary prey species that are essential to the conservation of the Cook Inlet beluga whale (NMFS 2016).

Biologists captured a total of 19 fish species in Knik Arm during nearshore beach seine and mid-channel surface tow net surveys in 2004 and 2005 (Houghton et al. 2005). Juvenile salmon (five species combined), three-spine stickleback (*Gasterosteus aculeatus*), saffron cod, and eulachon were among the most abundant species captured (Houghton et al. 2005).

Coho salmon was the most abundant juvenile salmon species in April; abundance increased to a peak in July before declining, with smaller numbers present in the nearshore Knik Arm through November (Houghton et al. 2005). Coho, and to a lesser degree sockeye salmon, had the largest and longest presence in Knik Arm of the juvenile salmonids. Juvenile pink and chum salmon had the shortest residency time in Knik Arm compared to other salmon species. Relatively small numbers of juvenile pink and chum salmon were captured in April; numbers peaked in May and June before declining sharply (Houghton et al. 2005). Juvenile Chinook salmon were captured in April; numbers increased to a peak in June and declined in August, with few present through October 2004. Juvenile Chinook salmon captured from between Cairn Point and Point Woronzof were primarily of William Jack Hernandez Sport Fish Hatchery origin (Houghton et al. 2005). Few sockeye were observed in Knik Arm before May, but sockeye were abundant from June through August, before declining in September and October (Houghton et al. 2005).

Tow net surveys confirmed the presence of substantial numbers of juvenile salmon throughout the open waters of Knik Arm (Houghton et al. 2005). Juvenile pink and chum salmon were more abundant in mid-channel tow net sampling than nearshore beach seining, which suggests that they may not have a strong association with shorelines in Knik Arm. Higher catches of juvenile coho and Chinook salmon in beach seines, as compared to tow net survey catches, suggest a closer association with shoreline habitat in Knik Arm. The numbers of juvenile sockeye salmon captured during tow net surveys as compared to beach seine hauls did not differ substantially (Houghton et al. 2005).

Based on the spring 1983 and 2004–2005 sampling efforts, Houghton et al. (2005) suggested the species most likely to contribute to beluga whale diets in Knik Arm include:

- April: Eulachon, saffron cod
- May: Eulachon, Chinook salmon, saffron cod
- June: Chinook salmon, saffron cod (questionable)
- July: Pink, chum, sockeye, and coho salmon
- August: Coho salmon, saffron cod
- September: Saffron cod, longfin smelt
- October: Saffron cod, longfin smelt
- November: Saffron cod

2.2.3.3 Zooplankton and Invertebrates

Fish and benthos sampling was conducted around the POA and north to Eagle Bay from July through November 2004, and from April through September 2005 (Houghton et al. 2005). These studies concluded that the area around the POA supports low benthic primary productivity, except for small patches of macroalgae (rockweed and annual green algae), which were present on occasional boulders and riprap, and in tidal marshes. Plankton samples included three species of copepods, four species of amphipods, one species of mysid, and several additional classes, orders, and families of freshwater invertebrates. The zooplankton samples were generally characterized by eight primary taxonomic groups including *Crangon* shrimp (spp.), copepods, amphipods, mysids, fish and larval fish, isopods, terrestrial invertebrates, and a marine polychaete (*N. limnicola)*. Overall, the most abundant group captured were larval fish (55 percent of total catch), followed by amphipods (10.7 percent), mysids (10.1 percent), copepods (9.1 percent), and *Crangon* spp. (2.3 percent). In general, zooplankton abundance was low, while crustaceans of sizes larger than could be consumed by juvenile salmon were abundant (Houghton et al. 2005).

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3 Species and Abundance of Marine Mammals

Marine mammals most likely to be observed within the upper Cook Inlet project area include harbor seals (*Phoca vitulina*), beluga whales (*Delphinapterus leucas*), and harbor porpoises (*Phocoena phocoena*; NMFS 2003; Table 3-1). Species that may be encountered infrequently or rarely within the project area are killer whales (*Orcinus orca*), humpback whales (*Megaptera novaeangliae*), and Steller sea lions (*Eumetopias jubatus*; Table 3-1). Marine mammals occurring in Cook Inlet that are not expected to be observed in the project area include the gray whale (*Eschrichtius robustus*), minke whale (*Balaenoptera acutorostrata*), and Dall's porpoise (*Phocoenoides dalli*). Data from the Alaska Marine Mammal Stranding Network database (NMFS unpublished data) provide additional support for the determination that these species rarely occur in upper Cook Inlet. Since 2011, only three humpback whales, one minke whale, and one Dall's porpoise have been documented as stranded in the portion of Cook Inlet north of Point Possession. All were dead upon discovery; it is unknown if they were alive upon their entry into upper Cook Inlet or drifted into the area with the tides. No gray whales were reported as stranded in upper Cook Inlet during this time period. For comparison, 22 beluga whale strandings were documented in upper Cook Inlet during the same time period, from a population that is currently about 327 individuals. With very few exceptions, minke whales, gray whales, and Dall's porpoises do not occur in upper Cook Inlet, and therefore take of these species is not requested in this application.

Except for the beluga whale and harbor seal, very small proportions of the populations of the four other species occur in upper Cook Inlet near the PCT Project site. This application assesses the potential impacts of the project on the following six species, which are discussed more fully in Section 4:

- Harbor seal
- Steller sea lion
- Harbor porpoise
- Killer whale
- Beluga whale
- Humpback whale

Table 3-1. Marine Mammals in or near the Project Area

Species or DPS	Abundance (Population/Stock)	MMPA Designation	ESA Listing	Occurrence in Project Area
Harbor seal	27,386 (Cook Inlet/Shelikof Strait)	None	None	Common
Western DPS Steller sea lion	50,983 (Western DPS)	Depleted & Strategic	Endangered	Rare
Harbor porpoise	31,046 (Gulf of Alaska)	Strategic	None	Occasional
Killer whale (Orca)	2,347 (Eastern North Pacific Alaska Resident)	None	None	Rare
	587 (Gulf of Alaska, Aleutian Islands, & Bering Sea Transient)	None	None	
Cook Inlet beluga whale	327[a] (Cook Inlet)	Depleted & Strategic	Endangered	Common
Humpback whale	11,398 (Hawaii DPS)	Depleted & Strategic	None	Rare
	3,264 (Mexico DPS)	Depleted & Strategic	Threatened	
	1,059 (Western North Pacific DPS)	Depleted & Strategic	Endangered	

[a] Mean of the past three population estimates for Cook Inlet beluga whales from 2012, 2014, and 2016 (Hobbs et al. 2016; Muto et al. 2018; Shelden et al. 2017).

Humpback whale population estimates: Wade et al. 2016.

Source for all other population estimates: Muto et al. 2018.

Note: DPS = Distinct Population Segment; ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act.

4 Affected Species Status and Distribution

4.1 Harbor Seal

4.1.1 Status and Distribution

Harbor seals inhabit waters all along the western coast of the United States, British Columbia, and north through Alaskan waters to the Pribilof Islands and Cape Newenham. There are 12 recognized stocks of harbor seals in Alaska. Harbor seals in the project area are members of the Cook Inlet/Shelikof stock; no other stock is present within the project area. Distribution of the Cook Inlet/Shelikof stock extends from Unimak Island, in the Aleutian Islands archipelago, north through all of upper and lower Cook Inlet (Muto et al. 2018).

The current abundance estimate for the Cook Inlet/Shelikof stock is based on aerial survey data from 1998 through 2011 and is estimated at 27,386 individuals, with a positive population growth trend of 313 seals per year (Muto et al. 2018). The estimated average annual subsistence harvest of the Cook Inlet/Shelikof stock between 2004 and 2008 was 233 individuals (Muto et al. 2018). Harbor seals are not listed under the Endangered Species Act (ESA) or designated as depleted or strategic under the MMPA, but like all marine mammals, they are protected under the MMPA.

4.1.2 Foraging Ecology

Harbor seals forage in marine, estuarine, and occasionally freshwater habitat. They are opportunistic feeders that adjust their local distribution to take advantage of locally and seasonally abundant prey (*as cited in* Payne and Selzer 1989; Baird 2001; Bjørge 2002). In Cook Inlet, harbor seals have been documented in higher concentrations near steelhead, Chinook, and salmon spawning streams during summer and may target more offshore prey species during winter (Boveng et al. 2012). Researchers have found that they complete both shallow and deep dives during hunting, depending on the availability of prey (Tollit et al. 1997).

Harbor seals are non-migratory, hauling out on rocks, reefs, beaches, and drifting glacial ice (Muto et al. 2018). Their movements are influenced by tides, weather, season, food availability, and reproduction, as well as individual sex and age class (Boveng et al. 2012; Lowry et al. 2001; Small et al. 2003).

4.1.3 Presence in Cook Inlet

Harbor seals inhabit the coastal and estuarine waters of Cook Inlet and are observed in both upper and lower Cook Inlet throughout most of the year (Boveng et al. 2012; Shelden et al. 2013). Recent research on satellite-tagged harbor seals observed several movement patterns within Cook Inlet (Boveng et al. 2012). In the fall, a portion of the harbor seals appeared to move out of Cook Inlet and into Shelikof Strait, northern Kodiak Island, and coastal habitats of the Alaska Peninsula. The western coast of Cook Inlet had higher usage by harbor seals than eastern coast habitats, and seals captured in lower Cook Inlet generally exhibited site fidelity by remaining south of the Forelands in lower Cook Inlet after release (Boveng et al. 2012).

The presence of harbor seals in upper Cook Inlet is seasonal. Harbor seals are commonly observed along the Susitna River and other tributaries within upper Cook Inlet during eulachon and salmon migrations (NMFS 2003). The major haulout sites for harbor seals are located in lower Cook Inlet; however, there are a few in upper Cook Inlet (Montgomery et al. 2007). During beluga whale aerial surveys of upper Cook Inlet from 1993 to 2012, harbor seals were observed 24 to 96 kilometers (15 to 60 miles) south-

southwest of Anchorage at the Chickaloon, Little Susitna, Susitna, Ivan, McArthur, and Beluga rivers (Shelden et al. 2013).

4.1.4 Presence in Project Area

Harbor seals are commonly observed within the project area, particularly near the mouth of Ship Creek (Cornick et al. 2011; Shelden et al. 2013). During annual marine mammal surveys conducted by NMFS since 1994, harbor seals have been observed in Knik Arm and in the vicinity of the POA (Shelden et al. 2013).

Harbor seals have been observed during construction monitoring at the POA from 2005 through 2011, and in 2016; data were unpublished for years 2005 through 2007 (Table 4-1; Cornick and Saxon-Kendall 2008, 2009; Cornick et al. 2010, 2011; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). Harbor seals were observed in groups of one to seven individuals (Cornick et al. 2011; Cornick and Seagars 2016).

Table 4-1. Summary of Harbor Seals Previously Documented at the POA

Year	Monitoring Effort			Total # of Sightings	Total # of Harbor Seals Observed	Survey
	Time Frame	# of Days	# of Hours			
2005	August 2–Nov. 28	51	374	NA	NA	POA: Scientific Monitoring
2006	April 26–Nov. 3	95	564	NA	NA	POA: Scientific Monitoring
2007	Oct. 9–Nov. 20	28	139	NA	NA	POA: Scientific Monitoring
2008	June 24–Nov. 14	86	612	2	2	POA: Scientific Monitoring
2008	July 24–Nov. 26	108	607[a]	1	1	POA: Construction Monitoring
2009	May 4–Nov. 18	86	783	1	1	POA: Scientific Monitoring
2009	March 28–Dec. 14	214	3,322[a]	NA	34[b]	POA: Construction Monitoring
2010	June 29–Nov. 19	87	600	0	0	POA: Scientific Monitoring
2010	July 21–Nov. 20	106	862[a]	13	13	POA: Construction Monitoring
2011	June 28–Nov. 15	104	1,202	32	57	POA: Scientific Monitoring
2011	July 17–Sept. 27	16	NA	2	2	POA: Construction Monitoring
2016	May 3–June 21	19	83.5	28	28	TPP: Marine Mammal Monitoring

[a] Intermittent in-water pile-driving hours.

[b] Additionally, three unidentified pinnipeds were documented.

Source: Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick and Seagars 2016; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006.

Notes: NA = Not available; the information was not provided in the reports. Reports for monitoring in 2005, 2006, and 2007 do not indicate whether or not harbor seals were sighted. The 2009 construction monitoring report does not indicate the total number of sightings, only the total number of harbor seals observed. POA = Port of Alaska; TPP = Test Pile Program.

4.1.5 Acoustics

Harbor seals respond to underwater sounds from approximately 1 to 180 kilohertz (kHz), with a functional high frequency limit around 60 kHz and peak sensitivity at about 32 kHz (Kastak and Schusterman 1995). Hearing ability in the air is greatly reduced (by 25 to 30 dB); harbor seals respond to sounds from 1 to 22.5 kHz, with a peak sensitivity of 12 kHz (Kastak and Schusterman 1995). NMFS (2018) defines harbor seals' hearing range as between 50 Hz and 86 kHz.

4.2 Steller Sea Lion

4.2.1 Status and Distribution

Two Distinct Population Segments (DPSs) of Steller sea lion occur in Alaska: the western DPS and the eastern DPS. The western DPS includes animals that occur west of Cape Suckling, Alaska, and therefore includes individuals within the project area. The western DPS was listed under the ESA as threatened in 1990, and its continued population decline resulted in a change in listing status to endangered in 1997. Since 2000, studies indicate that the population east of Samalga Pass (i.e., east of the Aleutian Islands) has increased and is potentially stable (Muto et al. 2018). For the region that encompasses Cook Inlet (Central Gulf of Alaska), the annual trend in counts (annual rates of change) of western DPS Steller sea lions is 4.33 for non-pups (adults and juveniles) and 4.22 for pups for the period 2003–2016 (Sweeney et al. 2016 from Muto et al. 2018). The most recent abundance estimate for the western DPS is 53,303 individuals (Muto et al. 2018).

4.2.2 Foraging Ecology

Steller sea lions feed on seasonally abundant prey throughout the year, predominately on species that aggregate in schools or for spawning. They adjust their distribution based on the availability of prey species. Principal prey include eulachon, walleye pollock, capelin, mackerel, Pacific salmon, Pacific cod, flatfishes, rockfishes, Pacific herring, sand lance, skates, squid, and octopus (Womble and Sigler 2006; Womble et al. 2009).

4.2.3 Presence in Cook Inlet

It is rare for Steller sea lions to be observed in upper Cook Inlet. Steller sea lions have not been documented in upper Cook Inlet during beluga whale aerial surveys conducted annually in June from 1994 through 2012 and in 2014 (Shelden et al. 2013, 2015).

4.2.4 Presence in Project Area

Steller sea lions have been observed near the POA in June 2009 (ICRC 2009a) and in May 2016 (Cornick and Seagars 2016). In 2009, there were three Steller sea lion sightings that were believed to have been the same individual (ICRC 2009a). In 2016, Steller sea lions were observed on 2 separate days. On 02 May 2016, one individual was sighted. On 25 May 2016, there were five Steller Sea lion sightings within a 50-minute period, and these sightings occurred in areas relatively close to one another (Cornick and Seagars 2016). Given the proximity in time and space, we believe these five sightings were of the same individual sea lion. All sightings occurred during summer, when the sea lions were likely attracted to ongoing salmon runs. However, considering the many hours of observations that have taken place in the area, the documented occurrence of Steller sea lions in the project area is rare.

4.2.5 Acoustics

The hearing capabilities of Steller sea lions are fairly similar to the hearing ranges of California sea lions, with slight variations in males and females (Kastelein et al. 2005; Mulsow and Reichmuth 2008). Kastelein et al. (2005) documented that the best hearing range for Steller sea lions is 1 to 16 kHz, but they are capable of detecting sounds between 60 Hz and 39 kHz (NMFS 2018a).

4.3 Harbor Porpoise

4.3.1 Status and Distribution

In Alaska, harbor porpoises are divided into three stocks: the Bering Sea stock, the Southeast Alaska stock, and the Gulf of Alaska stock. The Gulf of Alaska stock, which includes individuals in Cook Inlet, is currently estimated at 31,046 individuals (Muto et al. 2018). Dahlheim et al. (2000) estimated abundance and density of harbor porpoises in Cook Inlet from surveys conducted in the early 1990s. The estimated density of animals in Cook Inlet was 7.2 per 1,000 km^2, with an abundance estimate of 136 (Dahlheim et al. 2000), indicating that only a small number use Cook Inlet. Hobbs and Waite (2010) estimated a harbor porpoise density in Cook Inlet of 13 per 1,000 km^2 from aerial beluga whale surveys in the late 1990s. Neither of these surveys included coastlines, which are used heavily by harbor porpoises (Shelden et al. 2014).

4.3.2 Foraging Ecology

Harbor porpoises can be opportunistic foragers, but consume primarily schooling forage fish (Bowen and Siniff 1999). Harbor porpoises feed primarily on Pacific herring, squid, and smelts (North Pacific Universities 2015).

4.3.3 Presence in Cook Inlet

Harbor porpoises occur in both upper and lower Cook Inlet, and there has been an increase in harbor porpoise sightings in upper Cook Inlet over the past 2 decades (Shelden et al. 2014). Small numbers of harbor porpoises have been consistently reported in upper Cook Inlet between April and October. The highest monthly counts include 17 harbor porpoises reported between spring and fall 2006 (Prevel-Ramos et al. 2008), 14 in spring 2007 (Brueggeman et al. 2007), 12 in fall 2007 (Brueggeman et al. 2008a), and 129 between spring and fall 2007 (Prevel-Ramos et al. 2008). These observations occurred between Granite Point (near Tyonek) and the Susitna River. The number of porpoises counted more than once was unknown, indicating that the actual numbers are likely smaller than reported. The overall increase in the number of harbor porpoise sightings in upper Cook Inlet is unknown, although it may be an artifact from increased studies and marine mammal monitoring programs in upper Cook Inlet. It is also possible that the reduction in the Cook Inlet beluga whale range has opened up previously occupied beluga whale range to harbor porpoises (Shelden et al. 2014).

Harbor porpoises have been detected during passive acoustic monitoring efforts throughout Cook Inlet, with detections especially prevalent in lower Cook Inlet. In 2009, harbor porpoises were documented by using passive acoustic monitoring in upper Cook Inlet at the Beluga River and Cairn Point (Small 2009, 2010).

4.3.4 Presence in Project Area

Harbor porpoises have been observed within Knik Arm during monitoring efforts since 2005. During POA construction from 2005 through 2011 and in 2016, harbor porpoises were reported in 2009, 2010, and 2011 (Cornick and Saxon-Kendall 2008, 2009; Cornick and Seagars 2016; Cornick et al. 2010, 2011; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006; Table 4-2). In 2009, a total of 20 harbor porpoises were observed during construction monitoring, with sightings in June, July, August, October, and November. Harbor porpoises were observed twice in 2010, once in July and again in August. In 2011, POA monitoring efforts documented harbor porpoises five times, with a total of six individuals, in August, October, and November at the POA (Cornick et al. 2011). During other monitoring efforts conducted in Knik Arm, there were four sightings of harbor porpoises in 2005 (Shelden et al. 2014), and a single harbor porpoise was observed within the vicinity of the POA in October 2007 (URS 2008; Table 4-2).

Table 4-2. Summary of Harbor Porpoise Sightings near the POA

Year	Monitoring Effort			Total # of Sightings	Total # of animals	Survey
	Time Frame	# of Days	# of Hours			
2005	April–May	NA	NA	4	NA	Beluga Whale Habitat Use
2005	August 2–Nov. 28	51	374	NA	NA	MTRP: Scientific Monitoring
2006	April 26–Nov. 3	95	564	NA	NA	MTRP: Scientific Monitoring
2007	Oct. 9–Nov. 20	28	139	NA	NA	MTRP: Scientific Monitoring
2007	October	NA	NA	1	1	URS
2008	June 24–Nov. 14	86	612	0	0	MTRP: Scientific Monitoring
2008	July 24–Nov. 26	108	607[a]	0	0	MTRP: Construction Monitoring
2009	May 4–Nov. 18	86	783	0	0	MTRP: Scientific Monitoring
2009	March 28–Dec. 14	214	3,322[a]	NA	20	MTRP: Construction Monitoring
2010	June 29–Nov. 19	87	600	0	0	MTRP: Scientific Monitoring
2010	July 21–Nov. 20	106	862[a]	2	2	MTRP: Construction Monitoring
2011	June 28–Nov. 15	104	1,202	5	6	MTRP: Scientific Monitoring
2011	July 17–Sept. 27	16	NA	0	0	MTRP: Construction Monitoring
2016	May 3–June 21	19	85.3	0	0	TPP: Construction Monitoring

[a] Intermittent in-water pile-driving hours.

Source: Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick and Seagars 2016; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006; Shelden et al. 2014; URS 2008.

Notes: MTRP = Marine Terminal Redevelopment Project, TPP = Test Pile Program, NA = not available; the information was not provided in the reports. Reports for monitoring in 2005, 2006, and 2007 do not indicate whether or not harbor porpoises were sighted. The 2009 construction monitoring report does not indicate the total number of sightings, only the total number of harbor porpoises observed.

4.3.5 Acoustics

The harbor porpoise has the highest upper-frequency limit of all odontocetes investigated. Kastelein et al. (2002) found that the range of best hearing was from 16 to 140 kHz, with a reduced sensitivity around 64 kHz. Maximum sensitivity (about 33 dB re 1 µPa) occurred between 100 and 140 kHz. This maximum sensitivity range corresponds with the peak frequency of echolocation pulses produced by harbor porpoises (120–130 kHz; NMFS 2018a).

4.4 Killer Whale

4.4.1 Status and Distribution

There are three distinct ecotypes of killer whale in the northeastern Pacific Ocean: resident, transient, and offshore killer whales. There are two stocks that have the potential to be in the project area: the Eastern North Pacific Alaska Residents and the Gulf of Alaska, Aleutian Islands, and Bering Sea Transients. Both ecotypes overlap in the same geographic area; however, they maintain social and reproductive isolation and feed on different prey species. The population of the Eastern North Pacific

Alaska Resident stock of killer whales contains an estimated 2,347 animals and the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is estimated to contain 587 animals (Muto et al. 2018). Killer whales are rare in Cook Inlet, and most individuals are observed in lower Cook Inlet (Shelden et al. 2013).

4.4.2 Foraging Ecology

Resident killer whales are primarily fish-eaters, while transients consume marine mammals. In Cook Inlet, transient killer whales are known to feed on beluga whales, and resident killer whales are known to feed on anadromous fish (Shelden et al. 2003).

4.4.3 Presence in Cook Inlet

Killer whales are rare in upper Cook Inlet, and the availability of prey species largely determines the likeliest times for killer whales to be in the area. Killer whales have been sighted in lower Cook Inlet 17 times, with a total of 70 animals between 1993 and 2012 during beluga whale aerial surveys (Shelden et al. 2013); no killer whales were observed in upper Cook Inlet. Surveys over 20 years by Shelden et al. (2003) documented an increase in beluga whale sightings and strandings in upper Cook Inlet, beginning in the early 1990s. Several of these sightings and strandings report killer whale predation on beluga whales. The pod sizes of killer whales preying on beluga whales ranged from 1 to 6 individuals (Shelden et al. 2003). Passive acoustic monitoring efforts throughout Cook Inlet documented killer whales at Beluga River, Kenai River, and Homer Spit, although they were not encountered within Knik Arm. These detections were likely resident (fish-eating) killer whales. Transient killer whales (marine-mammal eating) likely have not been detected due to their propensity to move quietly through waters to track prey (Lammers et al. 2013; Small 2010).

4.4.4 Presence in Project Area

No killer whales were spotted in the vicinity of the POA during surveys by Funk et al. (2005), Ireland et al. (2005), or Brueggeman et al. (2007, 2008a, 2008b). Killer whales have also not been documented during any POA construction or scientific monitoring from 2005 to 2011 or during 2016 (Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008; Cornick and Seagars 2016; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). Very few killer whales, if any, are expected to approach or be in the vicinity of the project area during construction of the PCT.

4.4.5 Acoustics

The hearing of killer whales is well developed. Szymanski et al. (1999) found that they responded to tones between 1 and 120 kHz, and the most sensitive range was between 18 and 42 kHz. Their greatest sensitivity was at 20 kHz, which is lower than the most sensitive range of many other odontocetes, but it matches peak spectral energy reported for killer whale echolocation clicks.

4.5 Beluga Whale

4.5.1 Status and Distribution

Beluga whales appear seasonally throughout much of Alaska, except in the Southeast region and the Aleutian Islands. Five stocks are recognized in Alaska: the Beaufort Sea stock, eastern Chukchi Sea stock, eastern Bering Sea stock, Bristol Bay stock, and Cook Inlet stock (Allen and Angliss 2014). The Cook Inlet stock is the most isolated of the five stocks, since it is separated from the others by the Alaska Peninsula and resides year round in Cook Inlet (Laidre et al. 2000). Included in the Cook Inlet stock under the MMPA is a small group of beluga whales, fewer than 20 individuals, that is regularly observed in Yakutat

Bay. This small group of individuals is reproductively separated from individuals in Cook Inlet and is not known to enter Cook Inlet (Muto et al. 2018); therefore, the Yakutat Bay beluga whales are not discussed further. Only the Cook Inlet stock inhabits the project area.

The ADF&G conducted a survey of beluga whales in August 1979 and estimated 1,293 individuals (Calkins 1989). Although this survey did not include all of upper Cook Inlet, the area where almost all beluga whales are currently found during summer, it is the most complete survey of Cook Inlet prior to 1994 and incorporated a correction factor for beluga whales missed during the survey. Therefore, the ADF&G summary (Calkins 1989) provides the best available estimate for the historical beluga whale abundance in Cook Inlet. For management purposes, NMFS has determined that the carrying capacity of Cook Inlet is 1,300 beluga whales (65 *Federal Register* [FR] 34590) based on Calkins (1989).

No systematic population estimates for Cook Inlet beluga whales were conducted prior to 1994. NMFS began comprehensive, systematic aerial surveys of beluga whales in Cook Inlet in 1994. Unlike previous efforts, these surveys included the upper, middle, and lower inlet. These surveys documented a decline in abundance of nearly 50 percent between 1994 and 1998, from an estimate of 653 to 347 whales (Rugh et al. 2000). In response to this decline, NMFS initiated a status review on the Cook Inlet beluga whale stock pursuant to the MMPA and the ESA in 1998 (63 FR 64228). Annual abundance surveys were conducted each June from 1999 through 2012. In 2013, NMFS changed the survey to a biennial schedule because a detailed analysis determined there would be no decrease in the assessment quality if the number of surveying years was reduced (Hobbs 2013). The surveys between 1999 and 2014 indicated that the population continued to decline at an annual rate of 1.3 percent (Shelden et al. 2015; Muto et al. 2018). The most recent surveys were conducted in 2016 and produced an abundance estimate of 328 beluga whales (Table 4-3; Shelden et al. 2017). NMFS determines the abundance based on the average of the last three survey population estimates; therefore, the current abundance estimate is 327 beluga whales ((312 + 340 + 328)/3 = 327 [rounded up]; Table 4-3).

Table 4-3. Annual Cook Inlet Beluga Whale Abundance Estimates

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2016
367	435	386	313	357	366	278	302	375	375	321	340	284	312	340	328

Source: Allen and Angliss 2010, 2011; Hobbs and Shelden 2008; Hobbs et al. 2000, 2011, 2012; Rugh et al. 2003, 2004a, 2004b, 2005a, 2005b, 2005c, 2006a, 2006b, 2007; Shelden et al. 2013, 2015, 2017

Note: Surveys were not completed in 2013, 2015, and 2017.

In 1999, NMFS received petitions to list the Cook Inlet beluga whale stock as an endangered species under the ESA (64 FR 17347). However, NMFS determined that the population decline was due to overharvest by Alaska Native subsistence hunters and, because the Native harvest was regulated in 1999, listing this stock under the ESA was not warranted at the time (65 FR 38778). The Cook Inlet beluga whale stock was designated as depleted under the MMPA in 2000, indicating that the size of the stock was below its Optimum Sustainable Population (OSP) level (65 FR 34590). The population has remained below its OSP since the designation, but would be considered recovered once the population estimate rises above the OSP.

NMFS announced initiation of another Cook Inlet beluga whale status review under the ESA in 2006 (71 FR 14836) and received another petition to list the Cook Inlet beluga whale under the ESA (71 FR 44614). NMFS issued a decision on the status review on 20 April 2007, concluding that the Cook Inlet beluga whale is a DPS that is in danger of extinction throughout its range. Subsequently, NMFS issued a proposed rule to list the Cook Inlet beluga whale as an endangered species (72 FR 19821). On 17 October 2008, NMFS announced the listing of the population as endangered under the ESA (73 FR 62919). In 2010, a Recovery Team, consisting of a Science Panel and Stakeholder Panel, began meeting to develop a Recovery Plan for the Cook Inlet beluga whale. The Draft Recovery Plan was published in the *Federal Register* on 15 May 2015 and the Final Recovery Plan was published in the *Federal Register* on 05 January 2017.

4.5.2 Critical Habitat

On 11 April 2011, NMFS designated two areas of critical habitat for beluga whales in Cook Inlet (76 FR 20180). The designation includes 7,800 km^2 (3,013 mi^2) of marine and estuarine habitat within Cook Inlet, encompassing approximately 1,909 km^2 (738 mi^2) in Area 1 and 5,891 km^2 (2,275 mi^2) in Area 2 (Figure 4-1). From spring through fall, Area 1 critical habitat has the highest concentration of beluga whales due to its important foraging and calving habitat. Area 2 critical habitat has a lower concentration of beluga whales in spring and summer, but is used by beluga whales in fall and winter. Critical habitat does not include two areas of military usage: the Eagle River Flats Range on Fort Richardson and military lands of JBER between Mean Higher High Water and Mean High Water. Additionally, the POA, the adjacent navigation channel, and the turning basin were excluded from critical habitat designation due to national security reasons (76 FR 20180).

The designation identified Primary Constituent Elements (PCEs), essential features important to the conservation of the Cook Inlet beluga whale:

(1) Intertidal and subtidal waters of Cook Inlet with depths of <30 feet (MLLW) and within 5 miles of high- and medium-flow anadromous fish streams.

(2) Primary prey species, including four of the five species of Pacific salmon (chum, sockeye, Chinook, and coho), Pacific eulachon, Pacific cod, walleye Pollock, saffron cod, and yellowfin sole.

(3) The absence of toxins or other agents of a type or amount harmful to beluga whales.

(4) Unrestricted passage within or between the critical habitat areas.

(5) The absence of in-water noise at levels resulting in the abandonment of habitat by Cook Inlet beluga whales.

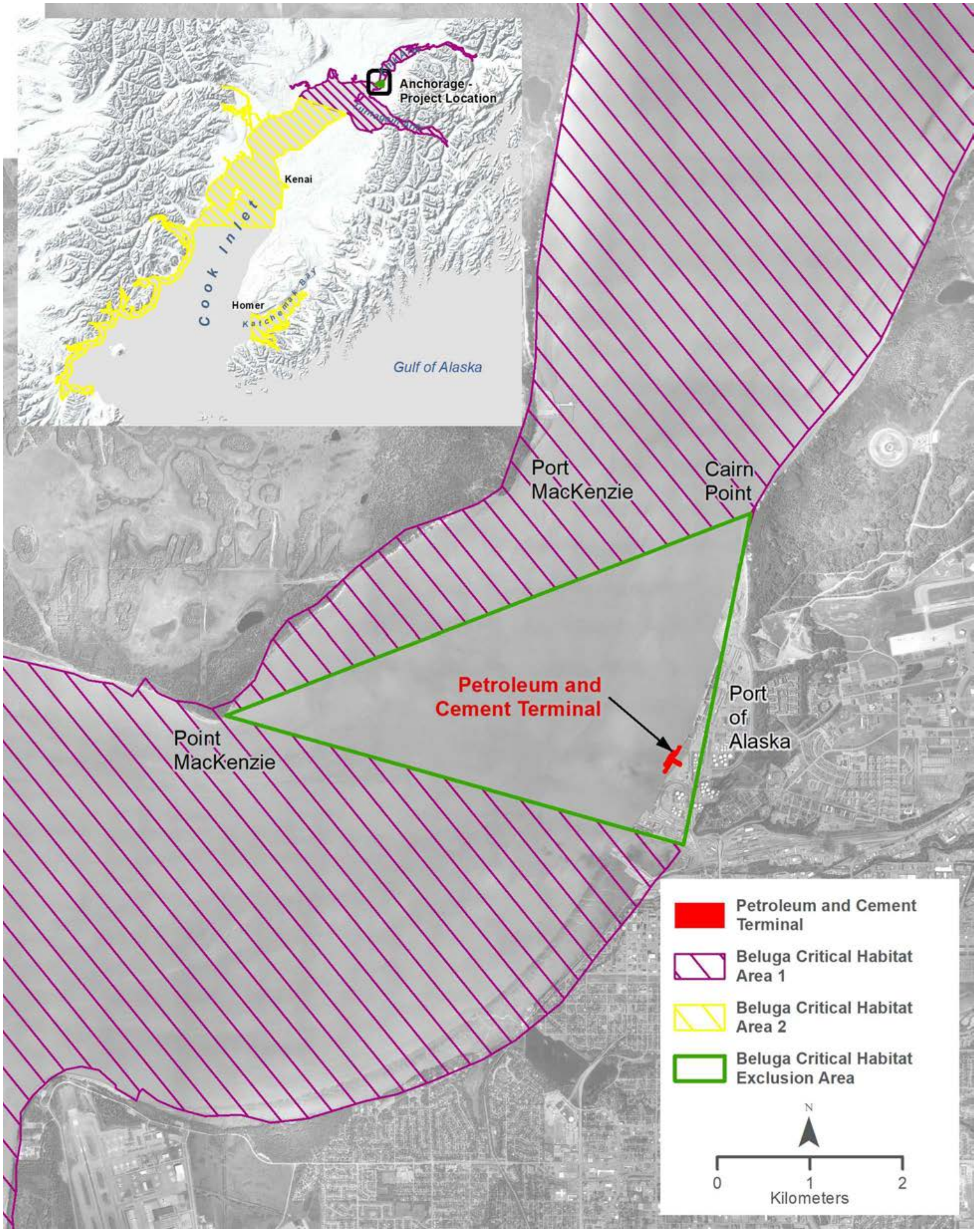

Figure 4-1. Cook Inlet Beluga Whale Critical Habitat and Exclusion Zone at POA

4.5.3 Foraging Ecology

Cook Inlet beluga whales feed on a wide variety of prey species, particularly those that are seasonally abundant. In spring, the preferred prey species are eulachon and cod. Other fish and invertebrate species found in the stomachs of beluga whales include porifera, polychaetes, mysids, amphipods, shrimp, crabs, and marine worms. Some of the species may be found in beluga whale stomachs from secondary ingestion because species such as cod feed on polychaetes, shrimp, amphipods, and mysids, as well as other fish (e.g., walleye pollock and flatfish) and invertebrates (Quakenbush et al. 2015).

From late spring through summer, most beluga whale stomachs sampled contained Pacific salmon, which corresponded to the timing of fish runs in the area. Anadromous smolt and adult fish concentrate at river mouths and adjacent intertidal mudflats (Calkins 1989). All five Pacific salmon species (i.e., Chinook, pink, coho, sockeye, and chum) spawn in rivers throughout Cook Inlet (Moore et al. 2000; Moulton 1997). Salmon, overall, represent the highest percent frequency of occurrence of prey species in Cook Inlet beluga whale stomachs. This suggests that their spring feeding in upper Cook Inlet, principally on fat-rich fish such as salmon and eulachon, is very important to the energetics of these animals (NMFS 2016).

In fall, as anadromous fish runs begin to decline, beluga whales return to consume fish species (cod and bottom fish) found in nearshore bays and estuaries. Stomach samples from Cook Inlet beluga whales are not available for winter (December through March), although dive data from beluga whales tagged with satellite transmitters suggest that they feed in deeper waters during winter (Hobbs et al. 2005), possibly on such prey species as flatfish, cod, sculpin, and pollock.

4.5.4 Distribution in Cook Inlet

4.5.4.1 Spring and Summer

During spring and summer, beluga whales are generally concentrated near the warmer waters of river mouths where prey availability is high and predator occurrence is low (Moore et al. 2000). In particular, beluga whale groups are seen in the Susitna River Delta, Knik Arm, and along the shores of Chickaloon Bay. Small groups have been recorded farther south in Kachemak Bay, Redoubt Bay (Big River), and Trading Bay (McArthur River) prior to 1996, but rarely thereafter. Since the mid-1990s, most beluga whales (96 to 100 percent) concentrate in shallow areas near river mouths in upper Cook Inlet, and they are rarely sighted in the central or southern portions of Cook Inlet during summer (Hobbs et al. 2008). Important calving grounds are located near the river mouths of upper Cook Inlet, and peak calving occurs between July and October (McGuire et al. 2016).

4.5.4.2 Fall and Winter

Data from tagged whales (14 tags between July and March 2000 through 2003) show that beluga whales continue to use upper Cook Inlet intensively between summer and late autumn (Hobbs et al. 2005). Beluga whales tagged with satellite transmitters continued to use Knik Arm, Turnagain Arm, and Chickaloon Bay as late as October, but some range into lower Cook Inlet to Chinitna Bay, Tuxedni Bay, and Trading Bay (McArthur River) in fall (Hobbs et al. 2005, Goetz et al. 2012a). From September through November, beluga whales move between Knik Arm, Turnagain Arm, and Chickaloon Bay (Hobbs et al. 2005; Goetz et al. 2012b). By December, beluga whales are distributed throughout the upper to mid-inlet. From January into March, they move as far south as Kalgin Island and slightly beyond in central offshore waters. Beluga whales make occasional excursions into Knik Arm and Turnagain Arm in February and March in spite of ice cover (Hobbs et al. 2005). Although tagged beluga whales moved widely around Cook Inlet throughout the year, there was no indication of seasonal migration in and out of Cook Inlet (Hobbs et al. 2005). Data from NMFS aerial surveys, opportunistic sighting reports, and satellite-tagged beluga whales confirm that they are more widely dispersed throughout Cook Inlet during winter (November–April), with animals found between Kalgin Island and Point Possession.

Generally fewer observations of beluga whales are reported from the Anchorage and Knik Arm area from November through April (76 FR 20180; Rugh et al. 2000, 2004a).

4.5.5 Presence in Project Area

Knik Arm is one of three areas in upper Cook Inlet where beluga whales concentrate during spring, summer, and early fall (Section 4.5.4). Most beluga whales observed in or near the POA are transiting between upper Knik Arm and other portions of Cook Inlet, and the POA itself is not considered high-quality foraging habitat. Beluga whales tend to follow their anadromous prey and travel in and out of Knik Arm with the tides. Use of Knik Arm is concentrated between August and October and is highest in September. Use of Knik Arm is lowest in winter (December through February) and remains low in spring and early summer (March–July; Funk et al. 2005; Hobbs et al. 2011, 2012; Rugh et al. 2000, 2004a, 2005a, 2006a, 2007; U.S. Army Garrison Fort Richardson 2009).

Goetz et al. (2012a) used distribution and group size data collected during annual aerial surveys between 1994 and 2008 to develop a predictive habitat model. This predictive model maps beluga whale density from zero to 1.12 whales per square kilometer in Cook Inlet. The highest predicted densities of beluga whales are in Knik Arm, near the mouth of the Susitna River, and in Chickaloon Bay. The model suggests that the density of beluga whales at the mouth of Knik Arm, near the POA, ranges between approximately 0.013 and 0.062 whales per square kilometer. The distribution presented by Goetz et al. (2012a) is generally consistent with beluga whale distribution documented in Upper Cook Inlet throughout ice-free months (NMFS 2016).

Several marine mammal monitoring programs and studies have been conducted at or near the POA during the last 10 to 12 years. These studies, summarized below, offer some of the best available information on the abundance of beluga whales in the project area.

4.5.5.1 2016 Test Pile Program Monitoring

In 2016, a marine mammal monitoring program was implemented during the PAMP 2016 TPP. Marine mammal monitoring was conducted during 19 non-consecutive days, with a total of 85.3 hours of monitoring observation from 03 May through 21 June 2016 (Cornick and Seagars 2016).

The monitoring effort and data collection were conducted at three locations: (1) the Anchorage Public Boat Dock, (2) the North End, which is located just above shore level at the north end of the POA, and (3) a roving observer with primary responsibility for the mandatory 100-meter shutdown zone and areas immediately adjacent to the PAMP 2016 TPP in-water activity that were not observable from other stations under all scenarios (Cornick and Seagars 2016).

4.5.5.2 POA Monitoring 2005 to 2011

The POA conducted NMFS-approved monitoring programs for beluga whales and other marine mammals focused at the POA from 2005 to 2011 (Table 4-4). Data on beluga whale sighting rates, groupings, behavior, and movements indicate that the POA is a relatively low-use area, in that beluga whales do not linger in the area, but pass through en route to other locations. They are observed most often in fall, with numbers peaking in late August to early October (Funk et al. 2005). Although groups with calves have been observed entering the POA area, data do not suggest that the area is an important nursery.

Although the POA scientific monitoring studies indicate that beluga whales are generally passing through the area, it is also used as foraging habitat by whales traveling between lower and upper Knik Arm. Individuals and groups of beluga whales have been observed passing through the area each year during monitoring efforts (Table 4-4). In all years, diving and traveling were the most common behaviors observed, with many instances of confirmed feeding. Sighting rates at the POA ranged from 0.05 to 0.4 whales per hour (Cornick and Saxon-Kendall 2008; Cornick et al. 2011; Markowitz and McGuire 2007;

Prevel-Ramos et al. 2006), as compared to 3 to 5 whales per hour at Eklutna, 20 to 30 whales per hour at Birchwood, and 3 to 8 whales per hour at Cairn Point (Funk et al. 2005), indicating that these areas are of higher use than the POA. In 2009, the mean sighting duration for 54 groups of beluga whales was 11.4 minutes (± 1.8 minutes), with a range of 1 to 61 minutes (Cornick et al. 2010). In 2011, the mean sighting duration for 62 groups of beluga whales was 16.4 minutes (± 3.5 minutes), with a range of 1 to 144 minutes. There were two observations that had long sighting durations of 144 minutes and 90 minutes; the remaining 60 observations had sighting durations less than 64 minutes (Cornick et al. 2011).

Data collected annually during monitoring efforts demonstrated that few beluga whales were observed in July and early August; numbers of sightings increased in mid-August, with the highest numbers observed in late August to mid-September. In all years, beluga whales have been observed to enter the project area while construction activities were taking place, including pile installation and dredging. The most commonly observed behaviors were traveling, diving, and suspected feeding. No apparent behavioral changes or reactions to in-water construction activities (e.g., displacement or abandonment of feeding behavior) were observed by either the construction workers or the scientific observers (Cornick et al. 2011).

Table 4-4. Beluga Whales Observed in the POA Area during Monitoring Programs

Year	Dates of Monitoring Effort	Monitoring Effort		Total Number of Groups[a] Sighted	Total Number of Beluga Whales	Monitoring Type
		# of Days	# of Hours			
2005	August 2–Nov. 28	51	374	21	157	MTRP: Scientific Monitoring
2006	April 26–Nov. 3	95	564	25	82	MTRP: Scientific Monitoring
2007	Oct. 9–Nov. 20	28	139	14	61	MTRP: Scientific Monitoring
2008	June 24–Nov. 14	86	612	74	283	MTRP: Scientific Monitoring
	July 24–Dec. 2	108	607[b]	59	431	MTRP: Construction Monitoring
2009	May 4–Nov. 18	86	783	54	166	MTRP: Scientific Monitoring
	March 28–Dec. 14	214	3,322[b]	NA	1,221	MTRP: Construction Monitoring
2010	June 29–Nov. 19	87	600	42	115	MTRP: Scientific Monitoring
	July 21–Nov. 20	106	862[b]	103	731	MTRP: Construction Monitoring
2011	June 28–Nov. 15	104	1,202	62	290	MTRP: Scientific Monitoring
	July 17–Sept. 27	16	NA	5	48	MTRP: Construction Monitoring
2016	May 3–June 21	19	85.3	9	10	TPP: Construction Monitoring

[a] Group can be one or more individuals.

[b] Intermittent in-water pile-driving hours.

Source: Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick and Seagars 2016; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006

Notes: MTRP = Marine Terminal Redevelopment Project, TPP = Test Pile Program, NA = not available; the information was not provided in the report. The 2009 construction monitoring report does not indicate the total number of sightings, only the total number of beluga whales observed.

4.5.5.3 Knik Arm Bridge and Toll Authority Baseline Study, 2004–2005

To assist in the evaluation of the potential impact of a proposed bridge crossing of Knik Arm north of Cairn Point, Knik Arm Bridge and Toll Authority (KABATA) initiated a study to collect baseline environmental data on beluga whale activity and the ecology of Knik Arm (Funk et al. 2005). Boat and land-based observations were conducted in Knik Arm from July 2004 through July 2005. Land-based observations were conducted from nine stations along the shore of Knik Arm. The three primary stations were located at Cairn Point, Point Woronzof, and Birchwood. The majority of beluga whales were observed north of Cairn Point. Temporal use of Knik Arm by beluga whales was related to tide height with most whale sightings at Cairn Point occurring at low tide. During the study period, most beluga whales using Knik Arm stayed in the upper portion of Knik Arm north of Cairn Point. Approximately 90 percent of observations occurred during the months of August through November, and only during this time were whales consistently sighted in Knik Arm. The relatively low number of sightings in Knik Arm throughout the rest of the year suggested that the whales were using other portions of Cook Inlet. In addition, relatively few beluga whales were sighted in spring and early to mid-summer. Beluga whales predominantly frequented Eagle Bay (mouth of Eagle River), Eklutna, and the stretch of coastline in between, particularly when they were present in high numbers (Funk et al. 2005).

4.5.5.4 Cook Inlet Beluga Whale Photo-ID Project

Beluga whales have persistent distinct natural markings that can be used to identify individuals. The Cook Inlet beluga whale photo-ID project has surveyed beluga whales in several areas throughout Cook Inlet. Knik Arm and the Susitna River Delta have been surveyed annually since 2005 (McGuire et al. 2013a). These annual surveys have indicated that beluga whales with calves and newborns use Knik Arm and Eagle Bay seasonally (McGuire et al. 2013b). In 2011, McGuire et al. (2013b) documented that 78 percent of the 307 beluga whales identified in Cook Inlet traveled to the Eagle Bay area. These data provide evidence that most, if not all, of the population visit this area at least once in their lifetime. Groups containing calves or neonates are more likely to be seen in Knik Arm, Eagle Bay, and the Susitna River Delta than other areas studied in upper Cook Inlet during the photo-ID project (McGuire et al. 2011, 2016).

4.5.6 Acoustics

In terms of hearing abilities, beluga whales are one of the most studied odontocetes because they are a common marine mammal in public aquariums around the world. Although they are known to hear a wide range of frequencies, their greatest sensitivity is around 10 to 100 kHz (Richardson et al. 1995), well above sounds produced by most industrial activities (<100 Hz or 0.1 kHz) recorded in Cook Inlet. Average hearing thresholds for captive beluga whales have been measured at 65 and 120.6 dB re 1 µPa at frequencies of 8 kHz and 125 Hz, respectively (Awbrey et al. 1988). Masked hearing thresholds were measured at approximately 120 dB re 1 µPa for a captive beluga whale at three frequencies between 1.2 and 2.4 kHz (Finneran et al. 2002). Beluga whales do have some limited hearing ability down to ~35 Hz, where their hearing threshold is about 140 dB re 1 µPa (Richardson et al. 1995). Thresholds for pulsed sounds are higher, depending on the specific durations and other characteristics of the pulses (Johnson 1991).

4.6 Humpback Whale

4.6.1 Status and Distribution

Humpback whales worldwide were designated as endangered under the Endangered Species Conservation Act in 1970, and were listed under the ESA at its inception in 1973. However, on 08 September 2016, NMFS published a final decision that changed the status of humpback whales under the ESA (81 FR 62259), effective 11 October 2016. The decision recognized the existence of 14 DPSs based on distinct breeding areas in tropical and temperate waters. Five of the 14 DPSs were classified under the ESA (4 endangered and 1 threatened), while the other 9 DPSs were delisted. No critical habitat was designated for any of the 5 listed DPSs.

The most comprehensive photo-identification data available suggest that approximately 89 percent of all humpback whales in the Gulf of Alaska are members of the Hawaii DPS, 11 percent are from the Mexico DPS, and less than 1 percent are from the western North Pacific DPS (Wade et al. 2016). The Hawaii DPS is not listed under the ESA, the Mexico DPS is listed as threatened, and the Western North Pacific DPS is listed as endangered. Members of different DPSs are known to intermix on feeding grounds; therefore, all waters off the coast of Alaska should be considered to have ESA-listed humpback whales.

The DPSs of humpback whales that were identified through the ESA listing process are not equivalent to existing MMPA stocks, and the stock delineations of humpback whales under the MMPA are currently under review. Until this review is complete, NMFS considers humpback whales in the Gulf of Alaska to be comprised primarily of whales belonging to the Central North Pacific stock, with a small proportion of animals belonging to the Western North Pacific Stock (Muto et al. 2018). Both stocks are designated strategic and depleted under the MMPA (Muto et al. 2018). The current estimates of humpback whale population sizes are 10,103 for the Central North Pacific stock and 1,107 for the Western North Pacific stock (Muto et al. 2018).

Humpback whales experienced large population declines due to commercial whaling operations in the early twentieth century. Barlow (2003) estimated the population of humpback whales at approximately 1,200 animals in 1966. The population in the North Pacific grew to between 6,000 and 8,000 by the mid-1990s. Current threats to humpback whales include vessel strikes, releases of chemicals or hydrocarbons into the marine environment, climate change, and commercial fishing operations (Muto et al. 2018).

4.6.2 Foraging Ecology

Humpback whales target aggregations of krill (Euphausiidae; Nemoto 1957) and small, schooling fish including herring (Krieger and Wing 1984), capelin (Witteveen et al. 2008), sand lance (Hazen et al. 2009), and juvenile salmon (Chenoweth et al. 2017). In Alaska waters, the species composition of prey taken by humpback whales varies, likely due to prey availability and individual preference (Witteveen et al. 2011).

4.6.3 Presence in Cook Inlet

Humpback whales are encountered regularly in lower Cook Inlet and occasionally in mid-Cook Inlet; however, sightings are rare in upper Cook Inlet. During aerial surveys conducted in summers between 2005 and 2012, Shelden et al. (2013) reported dozens of sightings in lower Cook Inlet, a handful of sightings in the vicinity of Anchor Point, in lower Cook Inlet, and no sightings north of 60° N latitude (approximately the latitude of the town of Ninilchik). Vessel-based observers participating in the Apache Corporation's 2014 survey operations recorded three humpback whale sightings near Moose Point in upper Cook Inlet and two sightings near Anchor Point, while aerial and land-based observers recorded no humpback whale sightings, including in the upper Inlet (Lomac-MacNair et al. 2014). Observers monitoring waters between Point Campbell and Fire Island during summer and fall 2011 and spring and summer 2012 recorded no humpback whale sightings (Brueggeman et al. 2013). Monitoring of Turnagain Arm during ice-free months between 2006 and 2014 yielded one humpback whale sighting (McGuire, unpublished data; cited in LGL and DOWL 2015).

4.6.4 Presence in Project Area

There have been few sightings of humpback whales in the vicinity of the project area. Humpback whales were not documented during POA construction or scientific monitoring from 2005 to 2011 or during 2016 (Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick and Seagars 2016; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). Observers monitoring the Ship Creek Small Boat Launch from 23 August to 11 September 2017 recorded two sightings, each of a single humpback whale, which was presumed to be the same individual (POA 2017b). One other humpback whale sighting has been recorded for the immediate vicinity of the project area. This event involved a stranded whale that was sighted near a number of locations in upper Cook Inlet before washing ashore at Kincaid Park in 2017; it is unclear as to whether the humpback whale was alive or deceased upon entering Cook Inlet waters.

4.6.5 Acoustics

There are no directly measured data for humpback whale hearing sensitivity. Recordings of vocalizations indicate that humpback whales produce sounds at frequencies between 20 Hz and 2 kHz (Darling 2015; Thompson et al. 1986). Au et al. (2006) recorded humpback vocalizations with harmonics up to 24 kHz. The hearing range of low-frequency cetaceans, including the humpback whale, is estimated at 7 Hz to 35 kHz (NMFS 2018a).

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5 Type of Incidental Take Authorization Requested

5.1 Incidental Harassment Authorization

Under Section 101 (a)(5)(D) of the MMPA, the POA requests authorization for the take of small numbers of marine mammals, by Level A and Level B harassment, incidental to pile installation and removal associated with construction of the PCT Project in Anchorage, Alaska. The POA requests an IHA that is valid for 1 year, from 01 April 2020 through 31 March 2021, and a second IHA that is valid for a second, subsequent year, from 01 April 2021 through 31 March 2022.

5.2 Take Authorization Request

The exposure assessment methodology used in this IHA application quantifies potential noise exposures of marine mammals resulting from pile installation in the marine environment (see Section 6). Results from this approach tend to overestimate exposures because all animals are assumed to be available to be exposed 100 percent of the time, and the formulas used to estimate transmission loss (TL) use idealized parameters. Additionally, this approach assumes that all exposed individuals are harassed contributing to overestimation of “take.”

The analysis for the construction of the PCT Project predicts a total of 1,169 potential marine mammal exposures during Phase 1 and 715 potential marine mammal exposures during Phase 2 (see Section 6 for estimates of exposures by species) to pile installation and removal over the course of the project that could be classified as Level A and Level B harassment as defined under the MMPA. The POA’s mitigation measures for construction of the PCT Project, described in Section 11, include monitoring of harassment zones to avoid and minimize take during pile installation and removal, and the use of a bubble curtain when feasible. These mitigation measures decrease the likelihood that marine mammals will be exposed to sound pressure levels that would cause Level A and Level B harassment, although the amount of that decrease cannot be quantified.

The POA does not expect that 1,884 harassment incidents will result from construction of the PCT Project. However, to allow for uncertainty regarding the exact mechanisms of the physical and behavioral effects, the POA is requesting authorization for take of 1,884 marine mammals (522 by Level A and 1,362 by Level B harassment) over the course of 2 construction seasons in this IHA application.

5.3 Method of Incidental Taking

Pile installation and removal associated with construction of the PCT Project, as outlined in Section 1, have the potential to disturb or displace small numbers of marine mammals. Specifically, the proposed action may result in “take” in the form of Level A and Level B harassment from underwater noise generated from pile installation and removal. See Section 11 for more details on the impact reduction and mitigation measures proposed.

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6 Take Estimates for Marine Mammals

The NMFS application process for IHAs requires applicants to determine the number of marine mammals by species that are expected to be incidentally harassed by an action, and the nature of the harassment (Level A or Level B). The PCT Project, as outlined in Section 1, has the potential to incidentally take marine mammals by harassment through exposure to sound associated with in-water pile installation and removal. Other activities associated with construction or operations of the PCT Project are not expected to result in take as defined under the MMPA.

6.1 Underwater Sound Descriptors

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water. Sound is generally characterized by several variables, including frequency and intensity. Frequency describes the sound's pitch and is measured in Hertz (Hz), while intensity describes the sound's loudness and is measured in decibels (dB). Decibels are measured using a logarithmic scale.

The method commonly used to quantify in-air sounds consists of evaluating all frequencies of a sound according to a weighting system reflecting that human hearing is less sensitive at low frequencies and extremely high frequencies than at mid-range frequencies. This is called A-weighting, and the decibel level measured is called the A-weighted sound level (dBA). A filtering method to reflect in-air hearing of marine mammals such as hauled-out pinnipeds has not been developed for regulatory purposes.

Underwater sounds are described by a number of terms that are commonly used and specific to this field of study (Table 6-1). Two common descriptors are the root-mean-square SPL (dB rms) during the pulse or over a defined averaging period, and sound exposure level (SEL). The rms level is the square root of the energy divided by a defined time period and referenced to a pressure of 1 microPascal (dB re 1 µPa). Unless otherwise indicated, in-water sound levels throughout this report are presented in dB re 1 µPa.

Spreading loss in marine waters is generally between 10 dB (cylindrical spreading) and 20 dB (spherical spreading), typically referred to as 10 log and 20 log, respectively. Cylindrical spreading occurs when sound energy spreads outward in a cylindrical fashion bounded by the bottom sediment and water surface, such as shallow water, resulting in a 3-dB reduction in noise level per doubling of distance. Spherical spreading occurs when the source encounters little to no refraction or reflection from boundaries (e.g., bottom, surface), such as in deep water, resulting in a 6-dB reduction in noise level per doubling of distance.

Table 6-1. Definitions of Some Common Acoustical Terms

Term	Definition
Decibel (dB)	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 microPascal (µPa) and for air is 20 µPa (approximate threshold of human audibility).
Sound Pressure Level (SPL)	Sound pressure is the force per unit area, usually expressed in µPa (or 20 microNewtons per square meter [m^2]), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 m^2. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure. Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency (Hz)	Frequency is expressed in terms of oscillations, or cycles, per second. Cycles per second are commonly referred to as Hertz (Hz). Typical human hearing ranges from 20 to 20,000 Hz.
Root Mean Square (rms), dB re 1 µPa	The rms level is the square root of the energy divided by a defined time period. For pulses, the rms has been defined as the average of the squared pressures over the time that comprises that portion of waveform containing 90 percent of the sound energy for one impact pile-driving impulse.
Ambient Noise Level	The background sound level, which is a composite of noise from all sources, near and far. The normal or existing level of environmental noise at a given location.
Sound Exposure Level (SEL), dB re 1 µPa^2-s	Proportionally equivalent to the time integral of the pressure squared in terms of dB re 1 µPa^2-s over the duration of the impulse. Similar to the unweighted SEL standardized in in-air acoustics to study noise from single events.
Cumulative SEL (SEL_{cum})	Measure of the total energy received during pile installation and removal, defined here as occurring within a single day.
Transmission Loss (TL)	Underwater TL is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water chemistry, and bottom composition and topography.

6.2 Applicable Noise Criteria

The MMPA defines Level A harassment as “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild.” The MMPA defines Level B harassment as “any act of pursuit, torment, or annoyance which 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.”

NMFS recently published updated Technical Guidance (NMFS 2018a) that is currently being used to assess effects of exposure to underwater anthropogenic sound on the hearing of marine mammals.

The Technical Guidance identifies the received levels, or thresholds, above which individual marine mammals are predicted to experience permanent changes (e.g., a permanent threshold shift [PTS]) in their hearing sensitivity from incidental exposure to underwater anthropogenic sound sources (NMFS 2018a). NMFS considers the Technical Guidance to represent the best available scientific information and, on this basis, suggests that these thresholds and weighting functions be used to assess the potential for PTS in marine mammals, which equates to Level A harassment under the MMPA. The models used to derive the acoustic thresholds for onset of PTS incorporate marine mammal auditory weighting functions in recognition of the variability found among marine mammal species in their hearing sensitivity. The auditory weighting functions are defined for five functional hearing groups: low-frequency (LF), mid-frequency (MF), and high-frequency (HF) cetaceans; and otariid in water (OW) and phocid in water (PW) pinnipeds (Table 6-2). Additionally, the models used to derive the PTS onset acoustic thresholds incorporate a time component in the form of a cumulative sound exposure level (SEL_{cum}) for both impulsive and non-impulsive sound, and a sound pressure level component by using peak sound level (L_{pk}) for impulsive sounds (NMFS 2018a).

Table 6-2. Marine Mammal Functional Hearing Groups and Representatives of Each Group that are found near the Port of Alaska

	Functional Hearing Group	Species	Generalized Hearing Range
Cetaceans	LF cetaceans	Humpback whales	7 Hz to 35 kHz
	MF cetaceans	Beluga whales, killer whales	150 Hz to 160 kHz
	HF cetaceans	Harbor porpoises	275 Hz to 160 kHz
Pinnipeds	PW pinnipeds underwater	Harbor seals	50 Hz to 86 kHz
	OW pinnipeds underwater	Steller sea lions	60 Hz to 39 kHz

Source: NMFS 2018a

Notes: LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; Hz = Hertz; kHz = kilohertz.

NMFS continues to use its interim criteria to assess Level B harassment levels. Under the interim guidance, Level B harassment by impulsive sounds, such as impact pile installation, occurs with exposure to an SPL of 160 dB rms for all marine mammals. Level B harassment by non-impulsive sounds, such as vibratory pile installation and removal, occurs with exposure to an SPL of 120 dB rms for all marine mammals unless empirical data exist to justify a higher threshold (see Section 6.3.1).

This application uses the Technical Guidance acoustic thresholds to calculate Level A harassment isopleths and the NMFS interim criteria to calculate Level B harassment isopleths (Table 6-3). The NMFS Companion User Spreadsheet (Version 2.0, 2018), provided by NMFS for use with the Technical Guidance (NMFS 2018a), was used as a basis to predict zones where the onset of a PTS in marine mammal hearing could occur. Since the onset of PTS based on SEL_{cum} is computed as farther from the pile than it would be using peak sound pressure computations, the onset of PTS is based on SEL computations; therefore, the onset of PTS based on peak sound levels is not provided in this assessment. Estimation of acoustic thresholds was conducted for conditions both with and without a sound-attenuating bubble curtain (Section 6.3.2.2).

Table 6-3. Summary of PTS Onset Acoustic Thresholds for Assessing Level A Harassment, and Acoustic Criteria for Assessing Level B Harassment, of Marine Mammals from Exposure to Noise from Impulsive (Pulsed) and Non-impulsive (Continuous) Underwater Sound Sources

<table>
<tr><th rowspan="2">Species Group</th><th colspan="4">PTS Onset Acoustic Thresholds (Received Level)</th></tr>
<tr><th>Hearing Group</th><th colspan="2">Impulsive (Pulsed or Intermittent)</th><th>Non-impulsive (Continuous)</th></tr>
<tr><td colspan="5">Level A Harassment</td></tr>
<tr><td rowspan="6">Cetaceans</td><td rowspan="2">LF</td><td>$L_{pk,flat}$</td><td>219 dB</td><td rowspan="2">$L_{E, LF, 24h}$: 199 dB</td></tr>
<tr><td>$L_{E, LF, 24h}$</td><td>183 dB</td></tr>
<tr><td rowspan="2">MF</td><td>$L_{pk,flat}$</td><td>230 dB</td><td rowspan="2">$L_{E, MF, 24h}$: 198 dB</td></tr>
<tr><td>$L_{E, MF, 24h}$</td><td>185 dB</td></tr>
<tr><td rowspan="2">HF</td><td>$L_{pk,flat}$</td><td>202 dB</td><td rowspan="2">$L_{E, HF, 24h}$: 173 dB</td></tr>
<tr><td>$L_{E, HF, 24h}$</td><td>155 dB</td></tr>
<tr><td rowspan="4">Pinnipeds</td><td rowspan="2">PW pinnipeds</td><td>$L_{pk,flat}$</td><td>218 dB</td><td rowspan="2">$L_{E, PW, 24h}$: 201 dB</td></tr>
<tr><td>$L_{E, PW, 24h}$</td><td>185 dB</td></tr>
<tr><td rowspan="2">OW pinnipeds</td><td>$L_{pk,flat}$</td><td>232 dB</td><td rowspan="2">$L_{E, OW, 24h}$: 219 dB</td></tr>
<tr><td>$L_{E, OW, 24h}$</td><td>203 dB</td></tr>
<tr><td colspan="5">Level B Harassment</td></tr>
<tr><td rowspan="3">Cetaceans</td><td>LF</td><td colspan="2" rowspan="5">160 dB rms</td><td rowspan="5">120 dB rms or ambient level</td></tr>
<tr><td>MF</td></tr>
<tr><td>HF</td></tr>
<tr><td rowspan="2">Pinnipeds</td><td>PW pinnipeds</td></tr>
<tr><td>OW pinnipeds</td></tr>
</table>

Source: NMFS 2018a

Note: PTS = permanent threshold shift; $L_{pk,flat}$ = peak sound pressure level (unweighted); $L_{E,24h}$ = sound exposure level, cumulative 24 hours; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; dB = decibels; rms = root mean square.

6.3 Description of Noise Sources

For the purposes of this IHA application, the sound field in Knik Arm is the existing ambient sound plus additional construction noise from the PCT Project. Pile installation and removal are anticipated to produce the highest in-water sound pressure levels (Section 6.3.2). A number of project activities will take place above marine waters (installation of utility lines and pipelines, construction of a hose tower, installation of decking), and no in-water noise is anticipated in association with their installation. Vessel noise will be generated by tugs and barges; however, noise from project vessels is not anticipated to have more than a negligible effect on beluga whales or other marine mammals.

6.3.1 Ambient Noise

Ambient noise is background noise that is comprised of many sources from multiple locations (Richardson et al. 1995). Ambient noise can vary with location, time of day, tide, weather, season, and frequency on scales ranging from 1 second to 1 year (Richardson et al. 1995). Ambient underwater noise levels in the project area are both variable and relatively high, primarily because of extreme tidal activity, elevated sediment loads in the water column, periodic high winds, the seasonal presence of ice, and anthropogenic activities. Sources of anthropogenic noise in the project area consist of dredging operations, boats, ships, oil and gas operations, construction noise, and aircraft overflights from JBER, all of which contribute to the high underwater noise levels in upper Cook Inlet (e.g., Blackwell and Greene 2003; KABATA 2011). These levels are consistent with other measurements conducted in Cook Inlet by Blackwell (2005).

Ambient levels were most recently measured near the POA in 2016 at two locations, one within the POA and one about 1 kilometer offshore of the POA, during a 3-day break in pile installation during the POA TPP (Austin et al. 2016). The median values of the background sound pressure levels from continuous 60-second sample averages were 117.0 dB at the nearshore location within the POA and 122.2 dB at the offshore location (POA 2016a). During the measurements, some typical sound signals were noted, such as noise from current flow and the passage of vessels. Throughout the data set, the offshore levels were consistently higher than those closer to the POA by 3 to 5 dB. Although different sound metrics were measured, the median levels are thought to be the most appropriate characterization of the nominal ambient conditions. A diurnal pattern to the ambient sound data was not apparent. Based on these measurements, an average ambient noise level of 122.2 dB will be used for the PCT Project.

6.3.2 Pile Installation and Removal

The primary sound-generating activities associated with construction of the PCT Project will be impact hammer installation and vibratory hammer installation and removal of steel pipe piles. Impact hammer pile installation produces impulsive sounds that typically have differing potential to cause physical effects to marine mammals, particularly with regard to hearing. Such sounds have the potential to result in physical injury because they are characterized by a relatively rapid rise in ambient pressure, followed by a period of diminishing, oscillating maximal and minimal pressures. Vibratory hammer installation and removal of steel pipe piles that will primarily be used to build temporary construction components will also take place during construction of the PCT Project.

To assist in assessment of sound levels produced by installation of piles in the POA environment, the POA conducted a PAMP TPP in 2016, which included impact and vibratory hammer pile installation of 48-inch piles. Two different noise attenuation systems were tested during the program: (1) a passive resonator system was deployed for four of the piles, and (2) a confined bubble curtain was deployed for an additional four piles (air flow to the bubble curtain was turned on and off intermittently during installation of one of these piles). Two piles were installed without any noise attenuation system. Results from installation of the unattenuated 48-inch piles during the 2016 TPP as well as results reported in the literature were used to develop acoustic parameters, including sound source levels (SSLs), for estimating potential exposure of marine mammals to elevated noise in the vicinity of the PCT Project.

6.3.2.1 Source Sound Levels

Unweighted Sound Levels

Acoustic data for 48-inch piles from the PAMP 2016 TPP were summarized for unattenuated impact pile installation conditions (Table 6-4) based on continuous measurements performed near the source and at about 1 kilometer from the pile, and were reported as median sound levels. The distances from the piles varied slightly from pile to pile; however, the positions are referred to generically as 10 meters (near 10-m) and 1,000 meters (near 1-kilometer [1-km]; Table 6-4, left column). Peak sound pressure level, rms, SEL, and TL coefficients were calculated for each unattenuated pile (Austin et al. 2016; Table 6-4). These values were each standardized to 10 meters (Table 6-4), and the standardized values were used for calculation of estimated zone sizes.

Table 6-4. Summary of Unweighted Sound Levels and TL Coefficients for Unattenuated Impact Pile Installation of 48-inch Piles for the 2016 TPP

Condition	Test Pile Program Pile		
	IP1	**IP5**	**IP6**[a]
Hammer Type[b]	H	D	D
Distance (m)	14	11	12
Peak, dB near 10-m Median UNWEIGHTED	213.2	212.5	208.7
rms, dB near 10-m UNWEIGHTED	199	197.9	193.2
SEL, dB near 10-m UNWEIGHTED	185.1	186.7	184.5
Distance (m)	959	968	977
Peak, dB near 1,000-m Median UNWEIGHTED	176.7	176	172.4
Peak, dB near 1,000-m 90th% UNWEIGHTED	178.2	178.6	173.8
rms, dB near 1,000-m UNWEIGHTED	163.1	166.5	158.4
SEL, dB near 1,000-m UNWEIGHTED	152.4	155.8	150.7
Distance (m)	10	10	10
Peak, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	215.4	213.1	209.9
rms, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	201.2	198.5	194.4
SEL, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	187.7	187.4	185.7

[a] Air bubble curtain turned on and off, but curtain structure remained in place and may have affected sound propagation. Therefore, this pile was not used to assess sound levels, as indicated by grayed text.

[b] H= hydraulic; D = diesel

[c] Computed using the near 10m levels and associated TL coefficient by Illingworth & Rodkin, Inc.

Source: Austin et al. 2016

Notes: dB = decibels; TL = transmission loss; SEL = sound exposure level; m = meters; rms = root mean square.

Sound levels for piles IP1, IP5, and IP6 are the average reported single-strike levels associated with each pile and do not take into account differences in the numbers of strikes used to install each pile. The data indicate that sound levels were comparable for piles IP1 and IP5 (Table 6-4). Levels were lower at both the near-source and far-field positions for the unattenuated driving of IP6, which was installed with a bubble curtain that was turned on and off during installation. The lower levels may have been an effect of the confined air bubble curtain fixture, which surrounded the pile even when the bubbles were turned off. As a result, sound levels for the unattenuated installation of pile IP6 were not used in this assessment (Table 6-4, column IP6). Given the small sample size and low variability in levels between the two completely unattenuated conditions (IP1 and IP5) and that the data did not indicate that one pile performed differently from the other or that data from one pile would be preferable to data from the other, the average from the piles were used. The near 10-m levels were standardized to actual distance of 10-m by determining the TL of both piles separately and using those TLs to calculate the levels at 10-m. In the case of SEL, this produced levels of 187.7 and 187.4 dB for IP1 and IP5, respectively. The levels at near 1,000-m were similarly standardized to an actual distance of 1,000-m which for SEL resulted in 152.1 and 155.8 dB for IP1 and IP5, respectively. The 10-m and 1,000-m levels were averaged, and the TL calculated. For SEL, this resulted in a TL of 16.85. The TL for peak level was calculated in the same manner. The TL for rms was taken directly from Austin et al. (2016).

Acoustic data for 144-inch piles are unavailable. To estimate the expected changes in hydroacoustic metrics such as amplitude associated with installation of 144-inch piles instead of 48-inch piles, data for 48-inch piles from the Caltrans Guidance (Caltrans 2015), along with theoretical analysis, were used. It was assumed that the radial vibration level for the 48- and 144-inch piles would be similar in that the increased thickness of 144-inch piles would be offset by the increased energy required to install the larger piles. Under this assumption, the SPL is expected to increase as the radiating surface area of the pile increases. Assuming the same length of pile, the surface area is a function of pile circumference. The circumference of a 144-inch pile is three times greater than the circumference of a 48-inch-diameter pile, and therefore the estimated radiated pressure would be three times greater. The SPL is then 20*Log of the pressure ratio, or a 9.5 dB increase from 48- to 144-inch piles (Table 6-5). This relationship was compared to the data in the Caltrans Guidance for steel piles of various diameters (Figure 6-1), for which the amplitude was set by matching the derived curve with the 48-inch pile level from the database. This relationship is best shown using a logarithmic relationship. Microsoft Excel, which provides a natural log function, was used for regression (Figure 6-1).

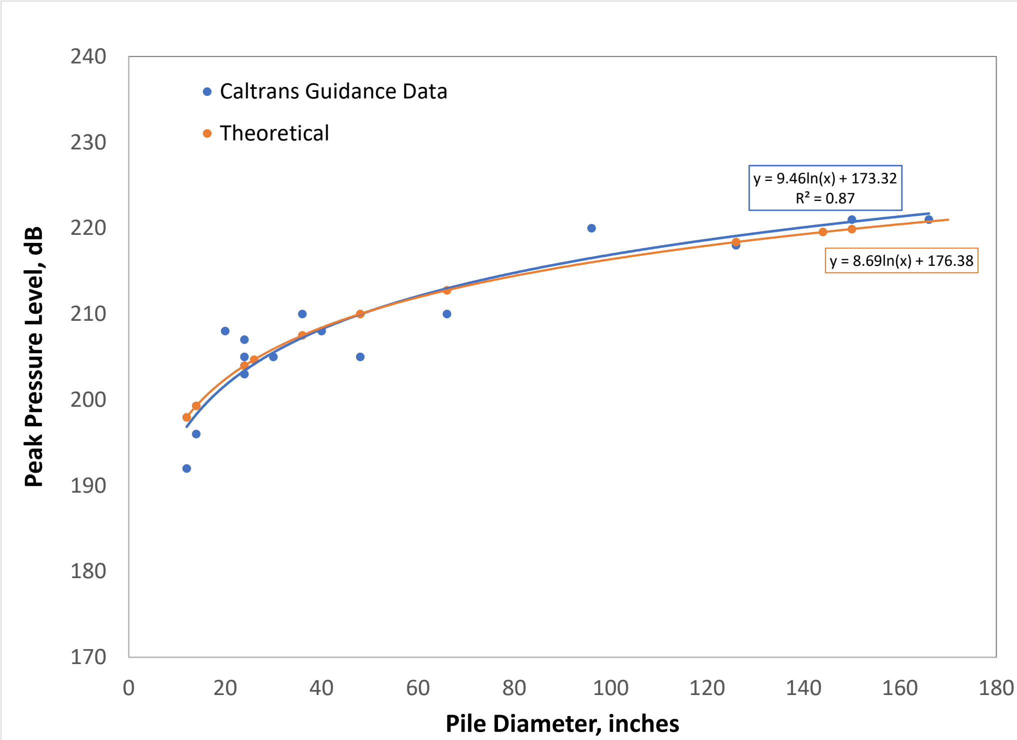

Figure 6-1. Relationship between Pile Diameter and Peak Sound Pressure Level Data from Caltrans (2015)

For peak SPLs, the theoretical curve matches the empirical curve closely. There are some deviations of up to about 5 dB; however, as indicated by the trend line, the coefficient of determination (R^2) was 0.87. Based on this result, the SPL for a 144-inch pile is expected to be 9.5 dB greater than for a 48-inch pile (Table 6-5). With this verification of peak SPLs, curve fitting of the empirical data in the Caltrans Guidance was also done for the SEL and rms levels (Figure 6-2). For the rms level, there are also deviations of about 5 dB for some piles; however, the R^2 value of 0.92 is higher than that for peak sound pressure levels. For SEL, the R^2 value is even higher at 0.95, although there are fewer data points (Figure 6-2).

Unweighted source levels for 36- and 24-inch piles were estimated using empirical measurements from other marine construction projects conducted by the U.S. Navy (Table 6-5). This comprehensive dataset showed higher levels than the Caltrans Guidance and was recommended for use by NMFS.

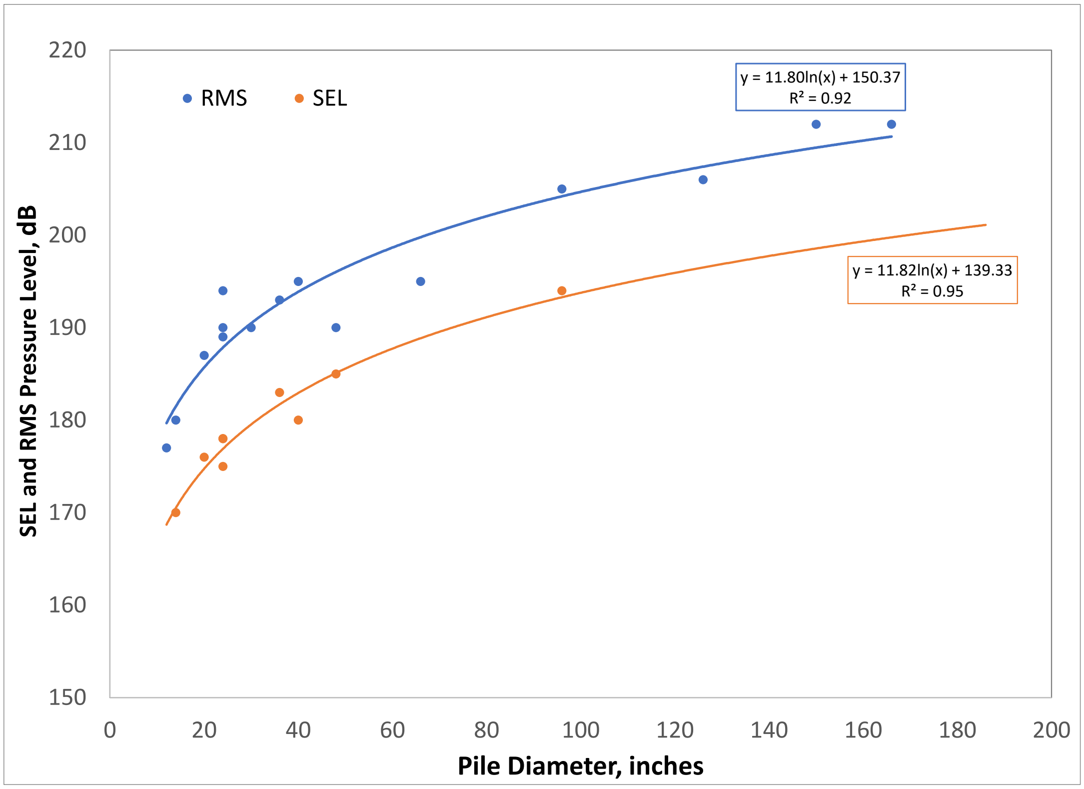

Figure 6-2. Logarithmic Fit of rms and SEL Data from Caltrans (2015)

Table 6-5. Estimates of Unweighted Underwater Sound Levels Generated during Vibratory and Impact Pile Installation and Vibratory Pile Removal, Standardized to 10 Meters

Method and Pile Type	Unweighted Sound Level at 10 Meters						Data Source for Unattenuated SSL
	Without Bubble Curtain			With Bubble Curtain			
Vibratory Hammer	**dB rms**			**7 dB Reduction, dB rms**			
144-inch steel	178			171			Caltrans 2015, I&R unpublished data
48-inch steel	168			161			POA Report of Findings 2016a
36-inch steel	166			159			U.S. Navy 2015
24-inch steel	161			154			U.S. Navy 2015
Impact Hammer	**dB rms**	**dB SEL**	**dB peak**	**7 dB Reduction**			
				dB rms	**dB SEL**	**dB peak**	
144-inch steel	209	198	220	202	191	213	Caltrans 2015, I&R unpublished data
48-inch steel	200	187	215	193	180	208	POA Report of Findings 2016a
36-inch steel	194	184	211	187	177	204	U.S. Navy 2015
24-inch steel	193	181	210	186	174	203	U.S. Navy 2015

Note: It is assumed that sound levels during pile installation and removal are similar. TL coefficient is 16.85 for impact pile installation for SEL and 18.35 for rms, and 16.50 for vibratory installation and removal, as measured during the 2016 Test Pile Program (POA 2016a). SSL = sound source level; dB = decibels; SEL = sound exposure level; POA = Port of Alaska; rms = root mean square.

Frequency Weighted Sound Levels

Numerical criteria presented in the NMFS Technical Guidance (NMFS 2018a) consist of both an acoustic SEL_{cum} threshold and an auditory weighting function. NMFS applies specific marine mammal auditory weighting functions for defining the onset of PTS for the five hearing groups: LF cetaceans, MF cetaceans, HF cetaceans, PW pinnipeds, and OW pinnipeds. Austin et al. (2016) analyzed the measured sound levels at both the near 10-m and near 1-km positions by applying the auditory weighting functions. Austin et al. (2016) also provided the one-third-octave band median sound levels for the measurements of impact pile installation, which were used to calculate the SEL values for MF and HF cetaceans for the near-10 m position (Table 6-6) for IP1. These were single-strike SEL levels for both the near 10-m and the near 1,000-m positions (Table 6-6). TL coefficients were computed for these data, since they vary by hearing group. However, only the unweighted TL coefficients were used to compute harassment zones.

Table 6-6. Median SEL Single-Strike Sound Levels and TL Coefficients for 48-inch Piles for the 2016 TPP

Condition	Test Pile Program Pile		
	IP1	**IP5**	**Average**
Hammer Type[a]	H	D	
Distance (m)	14	11	
SEL, dB near 10-m LF cetaceans	183.6	184.4	
SEL, dB near 10-m MF cetaceans	164.1[b]	165.3	
SEL, dB near 10-m HF cetaceans	161.2[b]	162.9	
SEL, dB near 10-m PW pinnipeds	176.3	173.7	
SEL, dB near 10-m OW pinnipeds	176.6	172.6	
Distance (m)	959	968	
SEL, dB near 1,000-m LF cetaceans	150.1	152.4	
SEL, dB near 1,000-m MF cetaceans	118.3	123.4	
SEL, dB near 1,000-m HF cetaceans	110.5	118.5	
SEL, dB near 1,000-m PW pinnipeds	141.1	141.0	
SEL, dB near 1,000-m OW pinnipeds	141.3	140.1	
TL Coefficient UNWEIGHTED	17.8	15.9	16.85
Distance (m)	10	10	10
SEL, dB computed to 10-m LF cetaceans[c]	185.0	185.0	185.0
SEL, dB computed to 10-m MF cetaceans[c]	164.1	164.1	164.1
SEL, dB computed to 10-m HF cetaceans[c]	160.2	160.2	160.2
SEL, dB computed to 10-m PW pinnipeds[c]	176.1	176.1	176.1
SEL, dB computed to 10-m OW pinnipeds[c]	176.3	176.3	176.3

[a] H= hydraulic; D = diesel

[b] Recomputed by Illingworth & Rodkin, Inc. using the unweighted one-third-octave band median sound levels.

[c] Computed using the near 10 m levels and associated TL coefficient by Illingworth & Rodkin, Inc.

Notes: dB = decibels; HF = high frequency; LF = low frequency; MF = mid-frequency; SEL = sound exposure level; TL = transmission loss; PW = phocid in water; OW = otariid in water; dB = decibels; m = meters.

NMFS does not apply auditory weighting functions to calculate Level B harassment isopleths. Unweighted SPLs at 10 meters and their TL coefficients, reported by Austin et al. (2016), were used in this assessment to calculate Level B isopleths for unattenuated impact installation of 48-inch piles (Table 6-7).

Table 6-7. Root Mean Square Single-Strike Sound Levels (dB) and TL Coefficients for 48-inch Piles for the 2016 TPP

Condition	Test Pile Program Pile		
	IP1	**IP5**	**Average**
Hammer Type[a]	H	D	
Distance (m)	14	11	
rms, dB near 10 m UNWEIGHTED	199.0	197.9	
Distance (m)	959	968	
rms, dB at 1,000 m UNWEIGHTED	163.1	166.5	
Distance (m)	10	10	10
rms, dB computed at 10 m UNWEIGHTED[b]	201.2	198.5	199.9
TL Coefficient UNWEIGHTED	19.2	17.5	18.35

[a] H= hydraulic; D = diesel

[b] Computed using the near 10m levels and associated TL coefficient by Illingworth & Rodkin, Inc.

Note: TL = transmission loss; dB = decibels; rms = root mean square; m = meters.

6.3.2.2 Effects of Noise Attenuation System on Pile Installation

The PAMP 2016 TPP evaluated the performance of two different types of noise attenuation systems: (1) a resonator system and (2) a confined air bubble curtain system. The project found that, in general, the confined air bubble system performed better than the resonator system, providing up to a 10-dB reduction in the single-strike SEL levels (POA 2016a). The measured reduction at 1 kilometer was not clear and was likely confounded by differences in location and propagation paths. For example, the highest levels measured at the 1-kilometer position were with the attenuation systems. It is intuitive that any reduction at the source would provide some level of reduction at greater distances.

The PAMP 2016 TPP used an air bubble curtain system that was developed specifically for use during the TPP. This system, in general, produced sound levels that were 9 to 12 dB lower at about 10 meters for impact installation and 9 dB lower for vibratory installation. At 1 kilometer, the levels were 4 to 8 dB lower (Austin et al. 2016). Modifications to the air bubble curtain that could improve performance are anticipated for the PCT Project. In addition, the system design may need to be modified to work with pile sizes and conditions specifically planned for the PCT Project. See Section 11 for anticipated bubble curtain specifications.

Similar test pile programs conducted by the Navy observed 7 dB reduction in noise level (U.S. Navy 2015). It is assumed for the PCT Project that a well-designed and robust air bubble noise attenuation system will achieve a mean reduction of 7 dB near the source and 7 dB away from the source (i.e., beyond 500 meters; U.S. Navy 2015) for both impact pile installation and vibratory pile installation and removal. As a conservative approximation, a 7 dB reduction rather than the 9 dB reduction observed during the PAMP 2016 TPP, was applied to this project.

6.3.2.3 Use of Two Hammers within a Day

During some phases of construction, three hammers could operate within a day and two could operate simultaneously for brief periods of time within a day. Construction sequencing for the PCT will not be known with certainty until construction begins and progresses. At this stage of project development, it is anticipated that the most likely combinations of piles that could be installed within a day include:

- Vibratory hammer installation of 24-inch piles and impact hammer installation of 48-inch trestle or loading platform piles, and
- Vibratory hammer installation of 36-inch piles and impact hammer installation of 48-inch piles trestle or loading platform piles.

It is not expected that two vibratory hammers will be operating at the same time.

NMFS (2018b) handles overlapping sound fields created by use of more than one hammer differently for impact and vibratory hammers. Based on the NMFS (2018b) guidance for use of two impact hammers simultaneously, it is unlikely that the two hammers would operate in synchrony, and therefore, the sound pressure levels will not be adjusted regardless of the distance between the hammers. In this case, each impact hammer will be considered to have its own independent harassment zone.

Based on the NMFS (2018b) guidance, simultaneous use of two vibratory hammers can create overlapping sound fields, resulting in additive effects of sound from the different hammers under certain conditions. In this case, although the sound from two sources near the same location results in louder sound levels than a single source alone, the sound levels cannot be added by standard addition because the decibel is measured on a logarithmic scale. For example, two sounds of equal level (plus or minus 1 dB) combine to raise the sound level by 3 dB. However, if two sounds differ by more than 10 dB, there is no combined increase in the sound level; the higher output covers any other sound (Table 6-8). This approach was used by WSDOT in assessment of potential impacts from sound associated with construction of the Seattle Multimodal Construction Project (82 FR 15497) and builds upon work by USDOT (1995) and Kinsler (2000). For marine mammal monitoring purposes, if the isopleth from one sound source encompasses a second sound source over a free sound field (i.e., no landmass separating the sound sources), then the sources are considered close enough to be a "combined sound source" and their sound levels are added (Table 6-8; NMFS 2018b) to determine the sound isopleth. The resulting isopleth is centered on the "combined source," which is the geometric centroid of the polygon that is formed by the sound sources.

During simultaneous use of an impact hammer and a vibratory hammer, the Level A zones for the impact hammer and the Level B zone for the vibratory hammer will be implemented.

Table 6-8. Rules for Combining Sound Levels Generated during Pile Installation and Removal

Hammer Types	Difference in SSL	Level A Zones	Level B Zone
Vibratory, Impact	Any	Use impact zones	Use vibratory zone
Impact, Impact	Any	Use zones for each pile size and number of strikes	Use zone for each pile size
Vibratory, Vibratory	0 or 1 dB	Add 3 dB to the higher source level	Add 3 dB to the higher source level
	2 or 3 dB	Add 2 dB to the higher source level	Add 2 dB to the higher source level
	4 to 9 dB	Add 1 dB to the higher source level	Add 1 dB to the higher source level
	10 dB or more	Add 0 dB to the higher source level	Add 0 dB to the higher source level

Source: Modified from USDOT 1995, WSDOT 2018, and NMFS 2018b

6.3.2.4 Inputs to the Calculation of Harassment Zone Sizes

Near Source Levels

The sizes of the zones for onset of PTS were computed based on SEL_{cum} levels. Computation of peak pressures were completed using the data presented in Table 6-4 and compared to the peak levels that would cause onset of PTS (Table 6-3). The farthest distance that unattenuated impact pile driving would exceed PTS onset would be less than 90 meters. This distance would be less than 40 meters for attenuated conditions. The onset of PTS (Level A) computations used the average near-source SEL single-strike sound levels from the two unattenuated piles from the 2016 TPP for each functional hearing group (Table 6-6). The unweighted rms source levels (Table 6-7) were standardized to 10 meters (Table 6-5) and used to evaluate the distances to the Level B isopleths using the interim NMFS guidance.

Weighting Frequency Adjustments

Weighting factor adjustments were applied to the one-third-octave band spectra data for the median single-strike SELs provided by Austin et al. (2016) for 48-inch piles. The frequency weightings were computed following the methods described in NMFS (2018); see for additional details and parameter definitions. The weighting functions were computed using the auditory weighting functions, expressed as:

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

where W(f) is the weighting function amplitude in dB at a particular frequency *(f)* in kHz. The function (filter) shape is determined by the weighting functions for each functional hearing group as defined by NMFS (2018; Table 6-9).

Table 6-9. Summary of Weighting and Exposure Function Parameters

Hearing Group	Low-frequency exponent a	High-frequency exponent b	Low-frequency cutoff ƒ1 (kHz)	High-frequency cutoff ƒ2 (kHz)	Weighting function gain C (dB)
LF cetaceans	1	2	0.2	19	0.13
MF cetaceans	1.6	2	8.8	110	1.2
HF cetaceans	1.8	2	12	140	1.36
PW pinnipeds (underwater)	1	2	1.9	30	0.75
OW pinnipeds (underwater)	2	2	0.94	25	0.64

Note: LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; kHz = kilohertz; Hz = Hertz; dB = decibels.

The filter shapes produced by this equation vary by marine mammal functional hearing group (Figure 6-3). The one-third-octave equivalents of these filter shapes were calculated by averaging the narrow-band filter data points over the band limits (Figure 6-4). Note that for these types of sounds, the frequency range was 16 to 20,000 Hz.

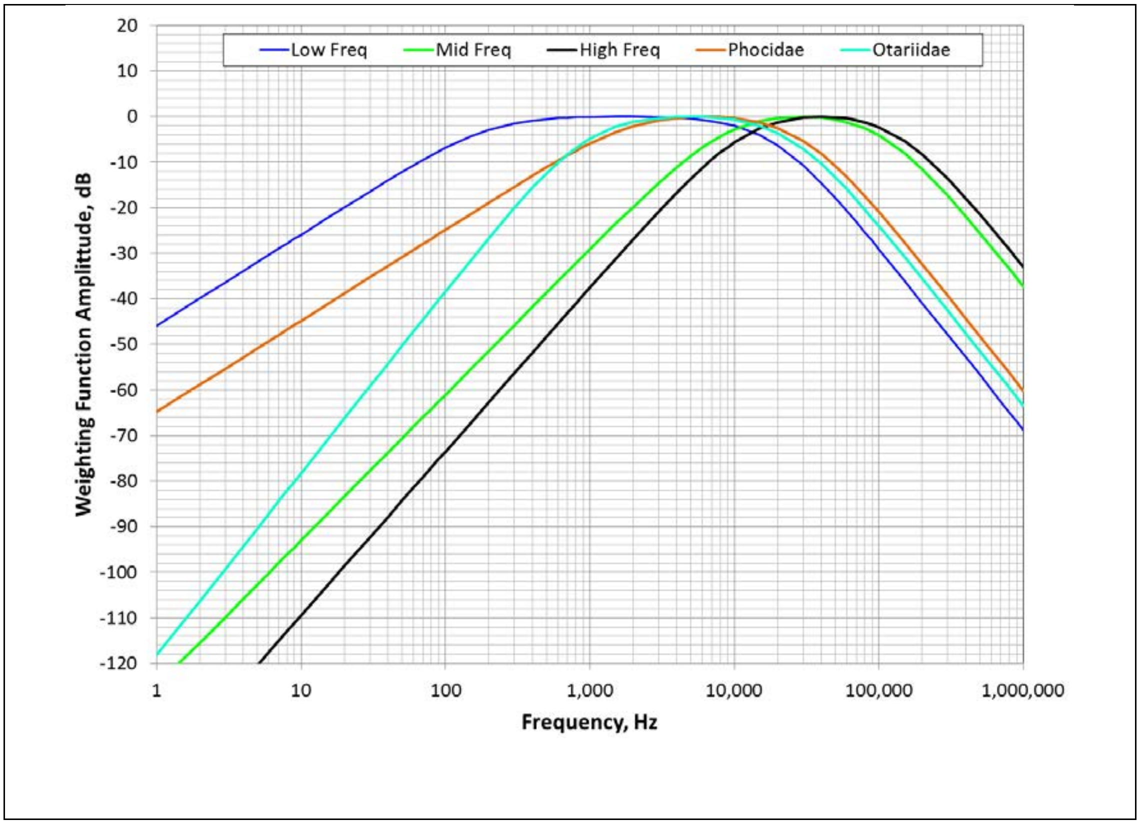

Figure 6-3. Marine Mammal Filters in Narrowband for the Parameters in Table 6-9 (range 1–1,000,000 Hz)

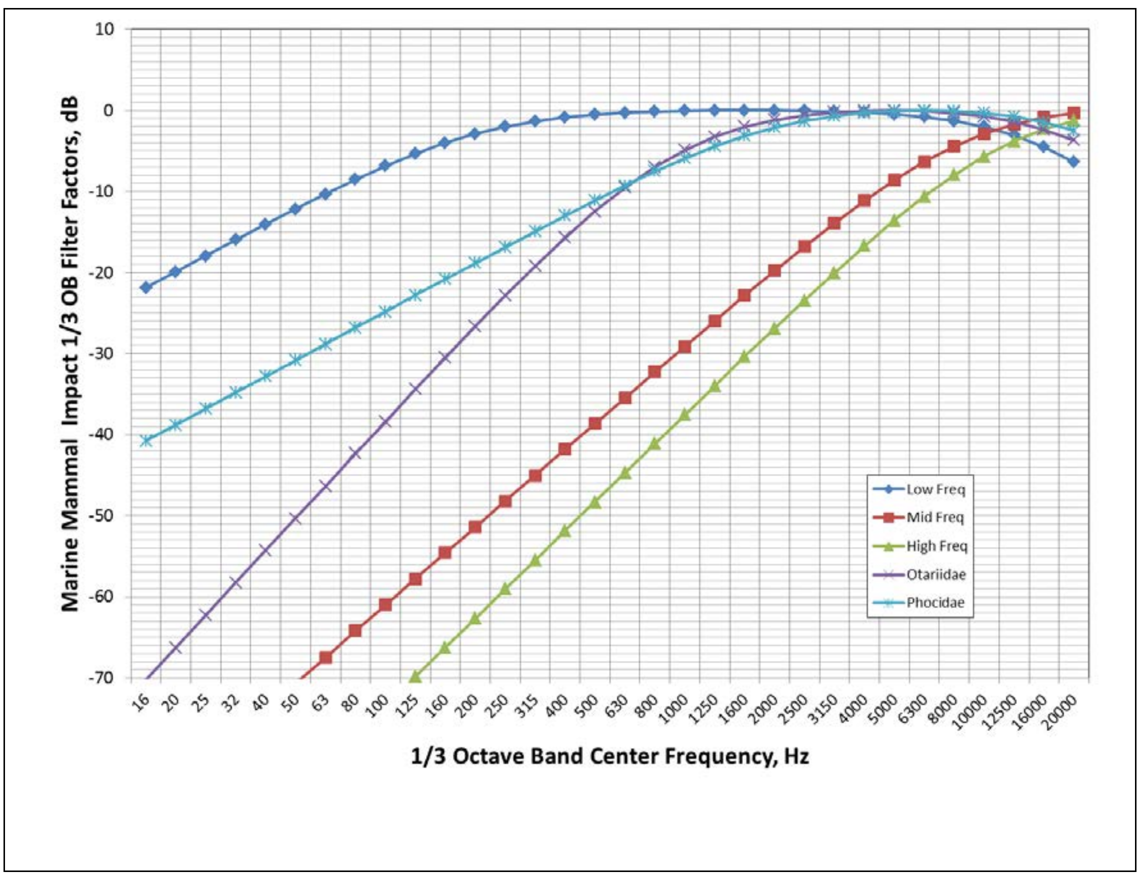

Figure 6-4. Marine Mammal Filters in One-third-Octave Bands for the Parameters in Table 6-9 (range 16–20,000 Hz)

The data points for the curves shown in Figure 6-4 are adjustments that are applied to the unweighted sound levels for each corresponding one-third-octave band and hearing group. The weighted one-third-octave band sound levels are then summed for each hearing group to compute the weighted sound levels both near the source (average distance of 12 meters) and near 1 kilometer from the pile. These are the weighted sound levels reported in Table 6-6 and Table 6-8.

It is expected that the spectrum emitted during impact installation of 144-inch piles would produce lower frequency noise than that emitted during installation of 48-inch piles. This can be seen using a comparison of spectra from 48-inch piles from the POA TPP and data from 36-inch piles from the U.S. Navy pile-driving program at the Bangor port facility (NAVFAC 2012). The spectra for the three unattenuated 48-in piles from the TPP are shown in Figure 6-5. The average for 48- and 36-inch spectra from the U.S. Navy project are compared in Figure 6-6. On average, there is a shift in one-third-octave band center frequency of one bandwidth, from 250 to 315 Hz for the 48- and 36-inch piles, respectively (Figure 6-6). This result is consistent with theoretical considerations as the frequency of the ring modes of the cylindrical pile are proportional to the square root of the cylinder radius (Den Hartog 1984, p 166). As a result, the first ring mode of a 48-inch pile will be lower in frequency than a 36-inch pile. Further, the radiation efficiency of a cylindrical structure is proportional to the cylinder radius (Lyon 1975, p 301). As a result, a larger diameter pile is expected to generate a higher sound level at a lower frequency for the given level of vibration (or hammer energy).

Based on the above considerations, the one-third-octave band spectrum for the 48-in pile would shift from the 250 Hz band indicated in Figure 6-5, by two bands down to the 160 Hz band for the spectrum of the 144-inch pile. In Figure 6-7, this shift is shown relative to the average 48-inch pile of Figure 6-5. To estimate an actual spectrum level, the overall level of the spectrum produced by this frequency shift was increased uniformly by 13 dB based on the discussion above and the empirical curve for SEL versus pile diameter (Figure 6-2). This estimated spectrum (Figure 6-8) for impact installation was used in determining the distances to marine mammal Level A thresholds for 144-inch piles once it was weighted properly by the weighting curve for the considered species. It was assumed that the spectral shape does not change significantly from that of the 48-inch piles for vibratory installation of 144-inch piles. For vibratory driving, the pile response is a forced response that is dictated by the frequency content of the driver. However, the overall level of the spectrum was shifted upwards to match the empirical sound pressure levels of Figure 6-2.

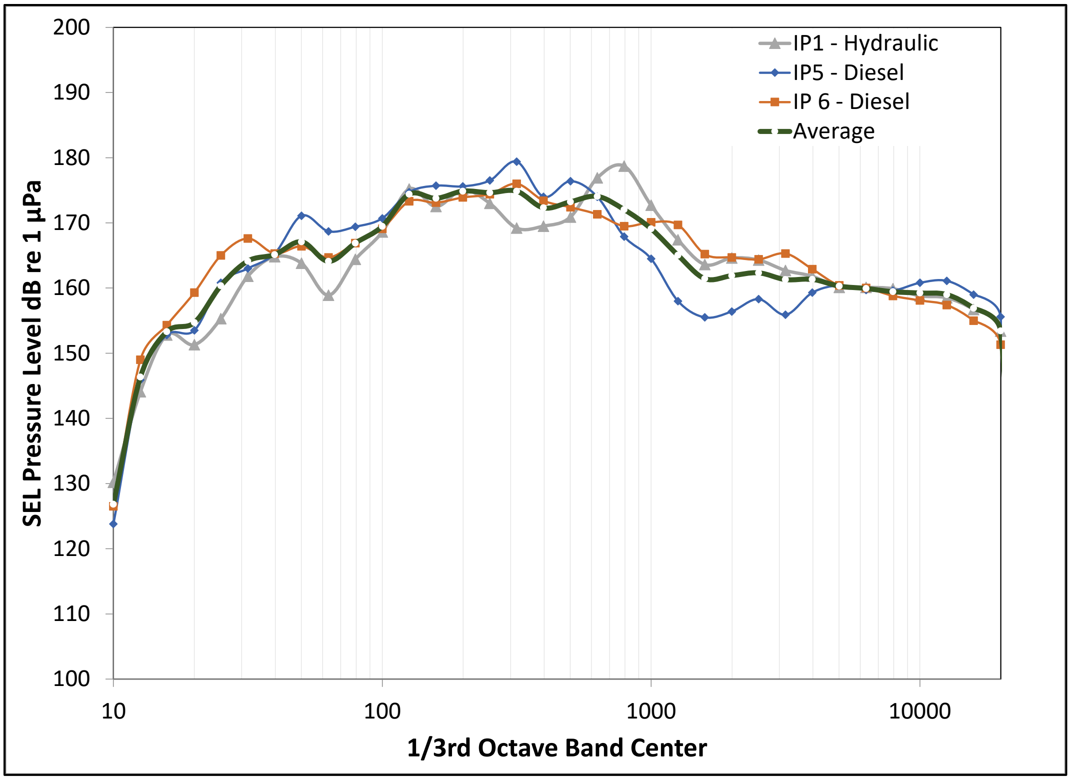

Figure 6-5. Frequency Spectrum Data for 48-inch Piles from the POA TPP

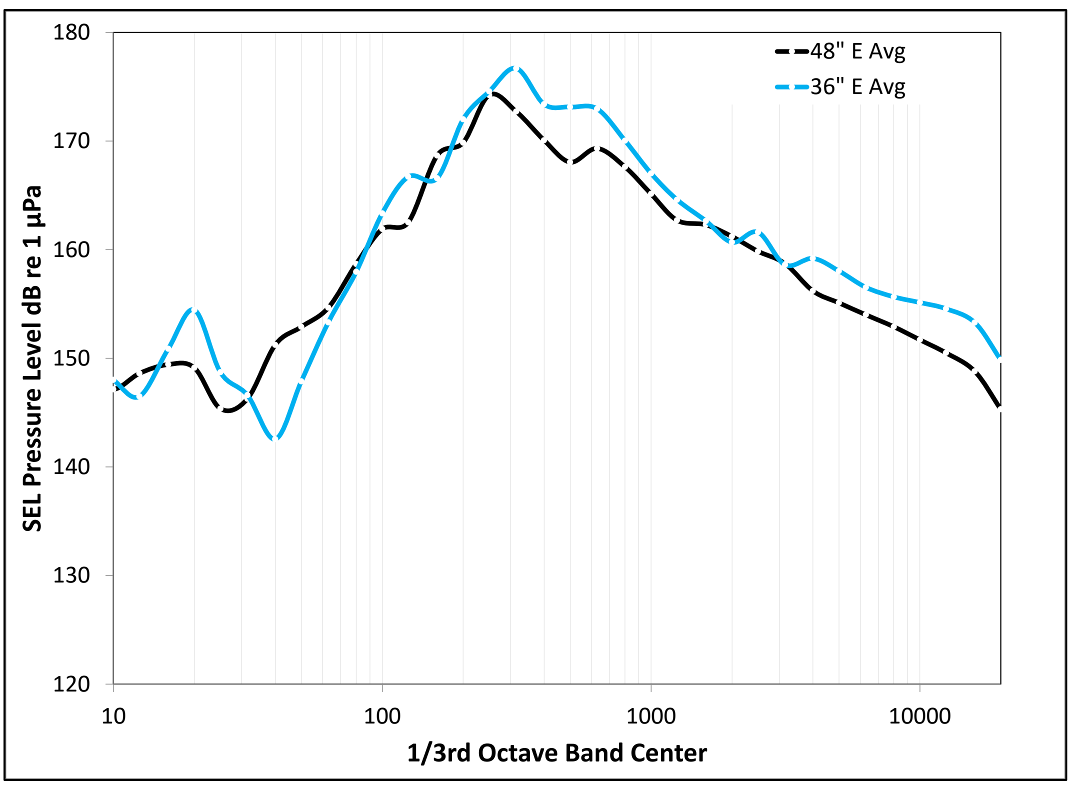

Figure 6-6. Spectral Differences for 48- and 36-inch Piles -- Navy Bangor Project (NAVFAC 2012)

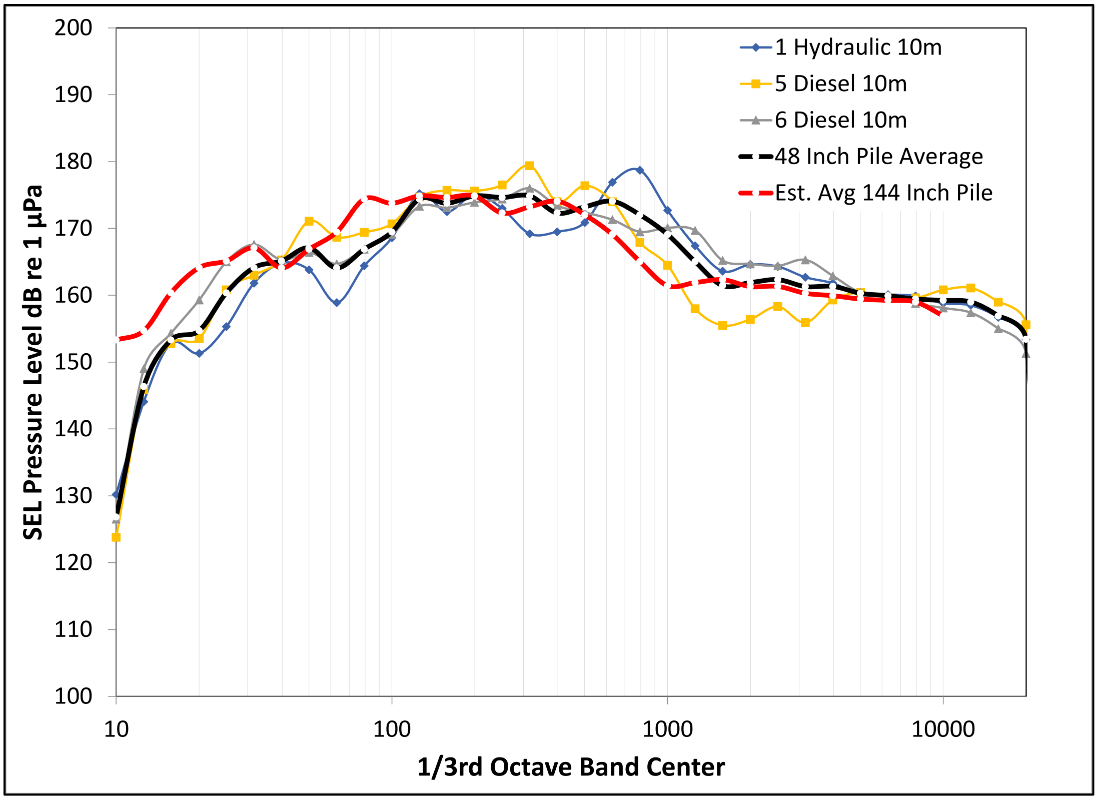

Figure 6-7. Spectral Shift Applied to the 48-inch Pile Data from the POA TPP to Account for Pile Diameter Increase to 144 Inches

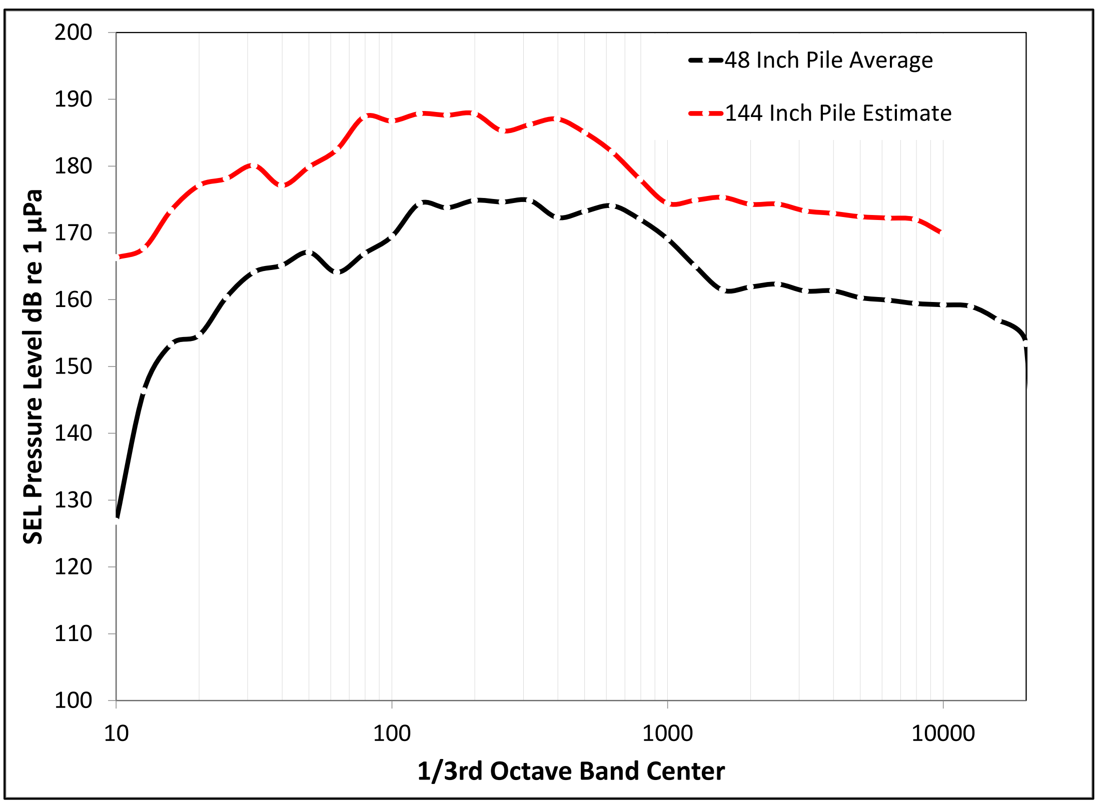

Figure 6-8. Estimated Spectrum for 144-inch Piles based on the 48-inch POA TPP Results

For 24- and 36-inch piles, it was assumed that the spectral shape did not change significantly from that of the 48-inch piles for impact and vibratory installation. The overall level of the spectrum for 48-inch piles was shifted lower to match the anticipated sound pressure levels of the smaller piles, indicated by Figure 6-2.

Transmission Loss and Transmission Loss Coefficients

Transmission loss is defined as the difference between the SSL and a predetermined sound level (e.g., the ambient noise or other sound level) at some distance. For the purposes of calculating the distances to Level B harassment thresholds, the TL is the difference between the measured SSLs and the Level B threshold for impulse or continuous noise.

TL coefficients are defined as the rate at which the SPL decreases with an increase in distance. TL coefficients were computed for single-strike SEL, rms, and peak pressure, based on the data reported by Austin et al. (2016) for vibratory and impact installation of 48-inch piles for the near 10-m and near 1-km locations (Table 6-4,Table 6-6, and Table 6-7). The TL coefficients calculated for vibratory and impact installation of 48-inch piles at the POA were also used to calculate zone sizes for 24-, 36-, and 144-inch piles. Based on the data from 48-inch piles, the average unweighted TL coefficient was used to calculate zone sizes for Level A and Level B harassment. Note that the TL coefficient associated with each functional hearing group would have produced a higher transmission loss and lower sound levels in the acoustic far-field environment.

6.3.2.5 Summary of Model Parameters

The underwater sound levels and TL coefficients that were used to model sound isopleths for each functional hearing group, pile size, type of pile installation, and type of harassment (onset of PTS assumed as Level A and Level B) are summarized in Table 6-10 through Table 6-14 for PCT construction.

Table 6-10. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 48 inch Piles — Permanent Platform and Access Trestle Piles, Impact Installation

Activity	# of Strikes per Pile	# of Piles per day	Hearing Group	Level A SELs and TL Coefficients				Level B rms and TL Coefficients		
				Single-Strike SEL at 10 m	TL Coefficient	SEL_{cum} Unatten.	SEL_{cum} Bubble Curtain	TL Coefficient	rms at 10 m Unatten.	rms at 10 m Bubble Curtain
48-in Platform Impact Pile Installation	2,300	1	Unweighted	187	16.85	221	214	18.35	200	193
			LF cetaceans	185	16.85	219	212	-	-	-
			MF cetaceans	164	16.85	198	191	-	-	-
			HF cetaceans	160	16.85	194	187	-	-	-
			PW pinnipeds	176	16.85	210	203	-	-	-
			OW pinnipeds	176	16.85	210	203	-	-	-
		2	Unweighted	187	16.85	224	217	18.35	200	193
			LF cetaceans	185	16.85	222	215	-	-	-
			MF cetaceans	164	16.85	201	194	-	-	-
			HF cetaceans	160	16.85	197	190	-	-	-
			PW pinnipeds	176	16.85	213	206	-	-	-
			OW pinnipeds	176	16.85	213	206	-	-	-
		3	Unweighted	187	16.85	225	218	18.35	200	193
			LF cetaceans	185	16.85	223	216	-	-	-
			MF cetaceans	164	16.85	202	195	-	-	-
			HF cetaceans	160	16.85	199	192	-	-	-

Table 6-10. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 48 inch Piles — Permanent Platform and Access Trestle Piles, Impact Installation

Activity	# of Strikes per Pile	# of Piles per day	Hearing Group	Level A SELs and TL Coefficients				Level B rms and TL Coefficients		
				Single-Strike SEL at 10 m	TL Coefficient	SEL_{cum} Unatten.	SEL_{cum} Bubble Curtain	TL Coefficient	rms at 10 m Unatten.	rms at 10 m Bubble Curtain
			PW pinnipeds	176	16.85	215	208	-	-	-
			OW pinnipeds	176	16.85	215	208	-	-	-
48-in Access Trestle Impact Pile Installation	3,000	1	Unweighted	187	16.85	222	215	18.35	200	193
			LF cetaceans	185	16.85	220	213	-	-	-
			MF cetaceans	164	16.85	199	192	-	-	-
			HF cetaceans	160	16.85	195	188	-	-	-
			PW pinnipeds	176	16.85	211	204	-	-	-
			OW pinnipeds	176	16.85	211	204	-	-	-
		2	Unweighted	187	16.85	225	218	18.35	200	193
			LF cetaceans	185	16.85	223	216	-	-	-
			MF cetaceans	164	16.85	204	197	-	-	-
			HF cetaceans	160	16.85	200	193	-	-	-
			PW pinnipeds	176	16.85	214	207	-	-	-
			OW pinnipeds	176	16.85	214	207	-	-	-
		3	Unweighted	187	16.85	227	220	18.35	200	193
			LF cetaceans	185	16.85	225	218	-	-	-
			MF cetaceans	167	16.85	206	199	-	-	-
			HF cetaceans	164	16.85	204	197	-	-	-
			PW pinnipeds	176	16.85	216	209	-	-	-
			OW pinnipeds	176	16.85	216	209	-	-	-

Note: TL = transmission loss; SEL = sound exposure level; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; dB = decibels; rms = root mean square; m = meters. SELcum based on 10*Log10 (# of pile strikes).

Table 6-11. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 48-Inch Piles — Permanent Platform and Access Trestle Piles, Vibratory Installation

Activity	Duration	# of Piles Per Day	Hearing Group	Single Second SEL/rms at 10 m	TL Coefficient	SEL_{cum} Unatten.	SEL_{cum} Bubble Curtain	TL Coefficient	rms at 10 m Unatten.	rms at 10 m Bubble Curtain
48 in Access Trestle Vibratory Pile Install	30 minutes	1	Unweighted	168	16.5	201	194	16.50	168	161
			LF cetaceans	165	16.5	197	190	-	-	-
			MF cetaceans	140	16.5	174	167	-	-	-
			HF cetaceans	136	16.5	169	162	-	-	-
			PW pinnipeds	157	16.5	189	182	-	-	-
			OW pinnipeds	157	16.5	190	183	-	-	-

Note: TL = transmission loss; SEL = sound exposure level; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; rms = root mean square; m = meters. SELcum based on 10*Log10 (# of seconds).

Table 6-12. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 24 Inch Piles — All Temporary Construction Piles, Vibratory Installation and Removal and Impact Installation

Activity	Duration[a]	# of Piles Per Day	Hearing Group	Single Second SEL/rms at 10 m	TL Coefficient	SEL$_{cum}$ Unatten.	SEL$_{cum}$ Bubble Curtain	TL Coefficient	rms at 10 m Unatten.	rms at 10 m Bubble Curtain
24-in Temporary Construction, Plumb Vibratory Installation and Removal	75 minutes	2	Unweighted	161	16.50	201	194	16.50	161	154
			LF cetaceans	158	16.50	197	190	-	-	-
			MF cetaceans	133	16.50	173	166	-	-	-
			HF cetaceans	129	16.50	168	161	-	-	-
			PW pinnipeds	150	16.50	189	182	-	-	-
			OW pinnipeds	150	16.50	190	183	-	-	-
		3	Unweighted	161	16.50	202	195	16.50	161	154
			LF cetaceans	158	16.50	199	192	-	-	-
			MF cetaceans	133	16.50	175	168	-	-	-
			HF cetaceans	129	16.50	170	163	-	-	-
			PW pinnipeds	150	16.50	191	184	-	-	-
			OW pinnipeds	150	16.50	191	184	-	-	-
		4	Unweighted	161	16.50	204	197	16.50	161	154
			LF cetaceans	158	16.50	200	193	-	-	-
			MF cetaceans	133	16.50	176	169	-	-	-
			HF cetaceans	129	16.50	171	164	-	-	-
			PW pinnipeds	150	16.50	192	185	-	-	-
			OW pinnipeds	150	16.50	193	186	-	-	-
	30 minutes	2	Unweighted	161	16.50	197	N/A	16.50	161	154
			LF cetaceans	158	16.50	193	N/A	-	-	-
			MF cetaceans	133	16.50	169	N/A	-	-	-
			HF cetaceans	129	16.50	164	N/A	-	-	-
			PW pinnipeds	150	16.50	185	N/A	-	-	-
			OW pinnipeds	150	16.50	186	N/A	-	-	-
		3	Unweighted	161	16.50	198	N/A	16.50	161	154
			LF cetaceans	158	16.50	195	N/A	-	-	-
			MF cetaceans	133	16.50	171	N/A	-	-	-
			HF cetaceans	129	16.50	166	N/A	-	-	-
			PW pinnipeds	150	16.50	187	N/A	-	-	-
			OW pinnipeds	150	16.50	187	N/A	-	-	-
24-inch Temporary Construction, Impact Proofing	100 Strikes	5	Unweighted	181	16.85	208	201	18.35	193	186
			LF cetaceans	179	16.85	206	199	-	-	-
			MF cetaceans	158	16.85	185	178	-	-	-
			HF cetaceans	154	16.85	181	174	-	-	-
			PW pinnipeds	170	16.85	197	190	-	-	-
			OW pinnipeds	170	16.85	197	190	-	-	-

Table 6-12. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 24 Inch Piles — All Temporary Construction Piles, Vibratory Installation and Removal and Impact Installation

Activity	Duration[a]	# of Piles Per Day	Hearing Group	Single Second SEL/rms at 10 m	TL Coefficient	SEL_{cum}		TL Coefficient	rms at 10 m	
						Unatten.	Bubble Curtain		Unatten.	Bubble Curtain
24-in Temporary Constr., battered Vibratory Installation and Removal	30 minutes	2	Unweighted	161	16.50	197	N/A	16.50	161	154
			LF cetaceans	158	16.50	193	N/A	-	-	-
			MF cetaceans	133	16.50	169	N/A	-	-	-
			HF cetaceans	129	16.50	164	N/A	-	-	-
			PW pinnipeds	150	16.50	185	N/A	-	-	-
			OW pinnipeds	150	16.50	186	N/A	-	-	-
		3	Unweighted	161	16.50	198	N/A	16.50	161	154
			LF cetaceans	158	16.50	195	N/A	-	-	-
			MF cetaceans	133	16.50	171	N/A	-	-	-
			HF cetaceans	129	16.50	166	N/A	-	-	-
			PW pinnipeds	150	16.50	187	N/A	-	-	-
			OW pinnipeds	150	16.50	187	N/A	-	-	-
	75 minutes	1	Unweighted	161	16.50	198	N/A	16.50	161	154
			LF cetaceans	158	16.50	194	N/A	-	-	-
			MF cetaceans	133	16.50	170	N/A	-	-	-
			HF cetaceans	129	16.50	165	N/A	-	-	-
			PW pinnipeds	150	16.50	186	N/A	-	-	-
			OW pinnipeds	150	16.50	187	N/A	-	-	-
		2	Unweighted	161	16.50	201	N/A	16.50	161	154
			LF cetaceans	158	16.50	197	N/A	-	-	-
			MF cetaceans	133	16.50	173	N/A	-	-	-
			HF cetaceans	129	16.50	168	N/A	-	-	-
			PW pinnipeds	150	16.50	189	N/A	-	-	-
			OW pinnipeds	150	16.50	190	N/A	-	-	-

Note: TL = transmission loss; SEL = sound exposure level; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; rms = root mean square; m = meters. SEL_{cum} based on $10*Log_{10}$ (# of seconds).

[a] Duration of installation and removal is dependent upon the depth to which each pile is driven into the substrate. See Table 1-2.

Table 6-13. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 144-Inch Piles — Permanent Mooring and Breasting Dolphin Piles, Impact and Vibratory Installation

Activity	# of Strikes per Pile	# of Piles Per Day	Hearing Group	Level A SELs and TL Coefficients				Level B rms and TL Coefficients		
				Single-Strike SEL at 10 m	TL Coefficient	SEL$_{cum}$ Unatten.	SEL$_{cum}$ Bubble Curtain	TL Coefficient	rms at 10 m Unatten.	rms at 10 m Bubble Curtain
144-in Mooring/Breasting Dolphin Impact Pile Installation	5,000	0.3	Unweighted	198	16.85	230	223	18.35	209	202
			LF cetaceans	195	16.85	226	219	-	-	-
			MF cetaceans	174	16.85	206	199	-	-	-
			HF cetaceans	170	16.85	202	195	-	-	-
			PW pinnipeds	185	16.85	217	210	-	-	-
			OW pinnipeds	185	16.85	216	209	-	-	-
		0.7	Unweighted	198	16.85	233	226	18.35	209	202
			LF cetaceans	195	16.85	230	223	-	-	-
			MF cetaceans	174	16.85	209	202	-	-	-
			HF cetaceans	170	16.85	205	198	-	-	-
			PW pinnipeds	185	16.85	221	214	-	-	-
			OW pinnipeds	185	16.85	220	213	-	-	-
Activity	**Duration**	**# of Piles Per Day**	**Hearing Group**	**Single Second SEL/rms at 10 m**	**TL Coefficient**	**SEL$_{cum}$ Unatten.**	**SEL$_{cum}$ Bubble Curtain**	**TL Coefficient**	**rms at 10 m Unatten.**	**rms at 10 m Bubble Curtain**
144-in pile Vibratory Installation	45 minutes	1	Unweighted	178	16.50	212	205	16.50	178	171
			LF cetaceans	175	16.50	209	202	-	-	-
			MF cetaceans	150	16.50	185	178	-	-	-
			HF cetaceans	146	16.50	180	173	-	-	-
			PW pinnipeds	167	16.50	201	194	-	-	-
			OW pinnipeds	167	16.50	201	194	-	-	-

Note: TL = transmission loss; SEL = sound exposure level; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; rms = root mean square; m = meters. SEL$_{cum}$ based on 10* Log_{10} (# of strikes and 10*Log_{10}(#of seconds).

Table 6-14. Underwater Sound Levels and TL Coefficients Used to Calculate Isopleth Distances for 36-Inch Piles — Temporary Construction Dolphin Template Piles, Vibratory Installation and Removal

Activity	Duration	# of Piles Per Day	Hearing Group	Single Second SEL/rms at 10 m	TL Coefficient	SEL_{cum}		TL Coefficient	rms at 10 m	
						Unatten.	Bubble Curtain		Unatten.	Bubble Curtain
36-in Temporary Construction Vibratory Installation and Removal	75 minutes	2	Unweighted	166	16.50	206	199	16.50	166	159
			LF cetaceans	163	16.50	202	195	-	-	-
			MF cetaceans	138	16.50	178	171	-	-	-
			HF cetaceans	134	16.50	173	166	-	-	-
			PW pinnipeds	155	16.50	194	187	-	-	-
			OW pinnipeds	155	16.50	195	188	-	-	-
		3	Unweighted	166	16.50	207	200	16.50	166	159
			LF cetaceans	163	16.50	204	197	-	-	-
			MF cetaceans	138	16.50	180	173	-	-	-
			HF cetaceans	134	16.50	175	168	-	-	-
			PW pinnipeds	155	16.50	196	189	-	-	-
			OW pinnipeds	155	16.50	196	189	-	-	-
		4	Unweighted	166	16.50	209	202	16.50	166	159
			LF cetaceans	163	16.50	205	198	-	-	-
			MF cetaceans	138	16.50	181	174	-	-	-
			HF cetaceans	134	16.50	176	169	-	-	-
			PW pinnipeds	155	16.50	197	190	-	-	-
			OW pinnipeds	155	16.50	198	191	-	-	-

Note: TL = transmission loss; SEL = sound exposure level; LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; rms = root mean square; m = meters. SEL_{cum} based on $10*Log_{10}$(# of seconds).

6.3.2.6 In-Air Noise Levels

To assess exposure of hauled-out pinnipeds to in-air noise, NMFS uses disturbance criteria for Level B harassment of 90 dB rms re 20 µPa for harbor seals, and 100 dB rms re 20 µPa for all other types of pinnipeds, including Steller sea lions. Note that all in-air sound discussed in this document is referenced to 20 µPa, unless otherwise noted. Measurements of in-air noise resulting from impact installation of 48-inch piles were collected during the 2016 TPP for both diesel and hydraulic hammers (Table 6-15). No other site-specific in-air noise measurements associated with pile installation are available, and no in-air measurements for 144-inch piles are available. The type of impact hammer that will be used during the PCT Project is not known at this time. In-air noise levels were higher during impact installation with the hydraulic hammer, and it is assumed that 102.5 dB is the highest anticipated in-air SSL for both phases of the PCT.

Table 6-15. Estimates for In-air Sound Levels (decibels) Generated during Pile Installation

Method and Pile Type	Sound Level (dB) at 15 meters
Diesel Impact Hammer 48-inch permanent steel pipe	101.0
Hydraulic Impact Hammer 48-inch permanent steel pipe	102.5

Source: POA 2016b

Notes: dB = decibels.

6.3.3 Other Underwater Noise Sources

Tugboats and Barges

Tugboats will be used in conjunction with barges to deliver materials to the project site as part of construction of the PCT Project. Tugboats will follow well-established shipping lanes in Cook Inlet and Knik Arm, which are currently used by recreational and commercial vessels. When in operation, the tugs will produce underwater sounds that could exceed the continuous sound disturbance threshold for marine mammals. While continuous sounds for tugs pulling barges have been reported to range from 145 to 166 dB re 1 µPa rms at 1 meter (3.3 feet) from the source, they are generally emitted at dominant frequencies of less than 5 kHz (Miles et al. 1987; Richardson et al. 1995; Simmonds et al. 2004). Thus, the dominant noise frequencies from tug propellers (<5 kHz) are lower than the dominant hearing frequencies for pinnipeds and toothed whales (Table 6-2; Richardson et al. 1995).

Though marine mammals will likely be exposed to noises that exceed the Level B harassment disturbance criterion during use of tugboats, it is unlikely that any individual will exhibit significant behavioral modifications that will harass that individual. Given the transitory nature of tugs, any disturbance to a particular individual will be limited in space and time. Knik Arm, and the project area specifically, are frequently traversed by barges, tugboats, commercial vessels and tenders, and recreational vessels, and shipping lanes are frequently subject to dredging, an activity that produces underwater noise. These ongoing activities contribute to elevated background noise levels in the project area. For example, in a 2001 acoustical study associated with construction at the POA, the highest sound levels of 149 dB at 100 meters were recorded from a tug pushing a barge (Blackwell and Greene 2003). Such activities, which are commonly associated with the POA, add to the baseline, and will influence ambient noise levels, masking sounds of project-related vessel use.

Southall et al. (2007) investigated marine mammal noise exposure criteria and provided guidance on the levels of underwater sound exposure that may elicit “significant behavioral disturbance.” Those behaviors considered at the lower end of their severity scaling matrix “would almost certainly not constitute behaviorally significant disturbance (or consequently Level B harassment under the MMPA).” Southall et al. (2007) found that exposures to multiple pulses in the 150 to 180 dB rms range generally have limited potential to induce avoidance behavior in pinnipeds. Similarly, although the effects of nonpulse exposures (i.e., vessel noise) on pinnipeds in water are poorly understood, limited studies (Costa et al. 2003; Jacobs and Terhune 2002; Kastelein et al. 2006) suggested that exposures between ~90 and 140 dB rms generally do not appear to induce strong behavioral responses in pinnipeds. Behavioral responses exhibited during exposure to non-pulse sounds from 90 to 140 dB rms, particularly those from 120 to 140 dB rms, ranged from no observable response to minor changes in locomotion or speed, direction, and/or dive profile with no avoidance of the sound source, and minor cessation or modification of vocal behavior. Due to the transitory nature of tugboats, none of these behavioral modifications are anticipated to disrupt critical life functions, displace animals from habitat, or cause them to avoid important habitat (e.g., foraging areas). As such, any disturbance from tugs will be discountable.

Southall et al. (2007) report the results of studies (Finley et al. 1990; LGL and Greeneridge 1986), documenting beluga whales' reactions to the approach and passage of ice-breaking ships in a remote area of Canada. These beluga whales were isolated stocks that were not accustomed to vessel traffic and associated noise, unlike Cook Inlet beluga whales. During these investigations, beluga whales were observed to respond to oncoming vessels by fleeing the area and modifying vocal behavior. However, there was some evidence of habituation and reduced avoidance 2 to 3 days after onset of the activity. Similarly, NMFS (2008b) reports that Alaska Native beluga whale hunters believe that Cook Inlet beluga whales are sensitive to boat noise, and will leave areas subjected to high use. However, in more heavily trafficked areas, beluga whales may habituate to vessel noise. For instance, beluga whales appear to be relatively tolerant of intensive vessel traffic in Bristol Bay and are commonly seen during summer at the POA, Alaska's busiest port. Indeed, Blackwell and Greene (2003) report that beluga whales were observed "within a few meters" of a large cargo ship, suggesting that they were not strongly affected by the sounds produced by the cargo ship.

Observations of beluga whales off the POA suggest that beluga whales are not harassed by vessel noise to the point of abandonment, although the whales may tolerate noise that would otherwise disturb them in order to feed or to conduct other biologically significant behaviors (NMFS 2008a). Knik Arm may serve as a biologically significant migratory corridor through which beluga whales must pass in order to reach primary feeding areas to the north, where ambient underwater sound levels are significantly lower than those at the POA, suggesting a relationship between reduced sound levels and beluga whale use (Blackwell and Greene 2003). In areas where they are subjected to heavy boat traffic, beluga whales are thought to habituate and become tolerant of the vessels, and exhibit plasticity in their choice of call types, rates, and frequencies in response to changes in the acoustic environment (Blackwell and Greene 2003). Overall, vessel-related sounds during the PCT Project are not expected to have more than a negligible effect on the beluga whales in the project area, and no take is requested for project-related vessel use.

6.4 Distances to Sound Thresholds and Areas

6.4.1 In-water Noise

Sound propagation and the distances to the sound isopleths at which a marine mammal exposed to those values would potentially experience a PTS based on the Technical Guidance (Level A isopleths) were estimated using a simple spreading loss model. This model is similar to the User Spreadsheet developed by NMFS for this purpose (NMFS 2018a). The NMFS User Spreadsheet computes the distances to isopleths for the different functional hearing groups based on an unweighted sound level with corresponding distance. The model applies simple Weighting Factor Adjustments for the five functional hearing groups and incorporates a duty cycle to account for the number of pile strikes (NMFS 2018a).

The simple spreading loss to account for sound propagation and the distances to the sound isopleths defined by NMFS for onset of PTS and Level B harassment of marine mammals were estimated based on the following:

$$TL = TL_c \log 10 \ (R/D)$$

Where

- TL is the difference between the reference SSL dB rms and the Level B threshold dB (122.2 dB for vibratory, 160 dB for impact);
- TL_c is the Transmission Loss coefficient;

- R is the estimated distance to where the sound level is equal to the Level B harassment threshold (122.2 dB for vibratory, 160 dB for impact); and
- D is the distance at which the SSL was measured.

The estimated distance to the onset of PTS and Level B harassment isopleths can be calculated by rearranging the terms in the above equation:

$$R = D\ 10^{(TL/TLc)}$$

For estimated distances to the onset of PTS, the SSL is based on the accumulated SEL (SEL_{cum}) from all pile strikes, which is computed based on the following:

$$SEL_{cum} = \text{Single-Strike SEL} + 10\ Log_{10}\,(\text{number of events})$$

Where number of events is expressed as pile strikes for impact pile driving or seconds for vibratory pile driving.

This model was used to predict distances to underwater sound levels generated by pile installation and removal as part of the PCT Project (Table 6-16 and Table 6-17).

Table 6-16. Calculated Distances to Level A and Level B Harassment Isopleths for Installation and Removal of Permanent Piles during Phase 1

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)
				Cetaceans			Pinnipeds		Cetaceans (LF, MF, HF) / Pinnipeds (PW, OW)
				LF	MF	HF	PW	OW	LF / MF / HF / PW / OW
48" Loading Platform Installation	Impact	**Bubble Curtain**	**1**	**655**	**34**	**766**	**376**	**36**	**629**
			2	**989**	**51**	**1,156**	**567**	**55**	
			3	**1,258**	**65**	**1,470**	**721**	**70**	
		Unattenuated	1	1,706	88	1,993	978	95	1,513
			2	2,574	132	3,008	1,475	143	
			3	3,274	168	3,826	1,877	182	
48" Access Trestle	Impact	**Bubble Curtain**	**1**	**767**	**39**	**897**	**440**	**43**	**629**
			2	**1,158**	**59**	**1,353**	**664**	**64**	
			3	**1,473**	**76**	**1,721**	**844**	**82**	
		Unattenuated	1	1,997	102	2,334	1,145	111	1,513
			2	3,014	155	3,521	1,727	168	
			3	3,833	197	4,479	2,197	213	
48" Loading Platform and Access Trestle Installation	Vibratory	**Bubble Curtain**	**1**	**5**	**1**	**7**	**3**	**0.3**	**2,247**
		Unattenuated	1	12	1	18	8	1	5,967
36" Temporary Access Work Trestle and Derrick Barge Vibratory Installation and Removal	Vibratory	**Bubble Curtain**	**3**	**12**	**1**	**17**	**8**	**1**	**1,699**
		Unattenuated	3	32	3	45	20	2	4,514
36" Temporary Access Work Trestle (restrikes)	Impact	**Bubble Curtain**	**1**	**45**	**2**	**52**	**26**	**2**	**296**
			2	**68**	**3**	**79**	**39**	**4**	
			3	**86**	**4**	**101**	**49**	**5**	
		Unattenuated	3	224	11	262	128	12	713
24" Temporary Construction Work Trestle, Access Trestle Template, Access Float and Temporary	Vibratory	**Bubble Curtain**	**4**	**7**	**1**	**10**	**4**	**0.4**	**846**
		Unattenuated	4	19	2	27	12	1	2,247

Table 6-16. Calculated Distances to Level A and Level B Harassment Isopleths for Installation and Removal of Permanent Piles during Phase 1

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)
				Cetaceans			Pinnipeds		Cetaceans / Pinnipeds
				LF	MF	HF	PW	OW	LF MF HF PW OW
24" Temporary Construct-ion Work Trestle, Access Trestle Template, Installation and Removal, Plumb	Impact[a]	**Bubble Curtain**	**5**	77	4	90	44	4	**261**
		Unattenuated	5	201	10	235	115	11	629
24" Temporary Dolphins, Installation and Removal, **battered**	Vibratory	Bubble Curtain	3	3	0.4	5	2	0.2	846
		Unattenuated	**3**	**9**	**1**	**13**	**6**	**1**	**2,247**

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; m = meters.

Table 6-17. Calculated Distances to Level A and Level B Harassment Isopleths for Installation and Removal of Temporary Piles during Phase 2

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)
				Cetaceans			Pinnipeds		Cetaceans / Pinnipeds
				LF	MF	HF	PW	OW	LF / MF / HF / PW / OW
144" Breasting and Mooring Dolphin Installation	Impact	**Bubble Curtain**	**0.3**	**2,286**	**117**	**2,672**	**1,311**	**127**	**1,945**
			0.7	**3,781**	**194**	**4,418**	**2,167**	**210**	
		Unattenuated	0.3	5,951	305	6,954	3,411	331	4,681
			0.7	9,840	505	11,498	5,640	547	
	Vibratory	**Bubble Curtain**	**1**	**24**	**3**	**34**	**15**	**1**	**9,069**
		Unattenuated	1	73	8	104	47	4	24,089
36” Dolphin Template Piles and Derrick Barge Vibratory Installation and Removal	Vibratory	**Bubble Curtain**	**4**	12	1	17	8	1	**1,699**
		Unattenuated	4	38	4	54	24	2	4,514
24” Temporary Dolphins Vibratory Installation and Removal, plumb	Vibratory	**Bubble Curtain**	**3**	**3**	**0**	**5**	**2**	**0**	**846**
		Unattenuated	3	9	1	13	6	1	2,247
24” Temporary Dolphins Vibratory Installation and Removal, battered	Vibratory	Bubble Curtain	3	3	0	5	2	0	846
		Unattenuated	**3**	**9**	**1**	**13**	**6**	**1**	**2,247**

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; m = meters.

As discussed in Section 1.3.5, it may not be possible to use a bubble curtain on piles installed or removed in shallow water or piles installed or removed “in the dry,” e.g., at times when the tide is low and the installation location is dewatered. When a pile is installed or removed in the dry or in very shallow water conditions, it will be assumed that no exposure of marine mammals to noise that is defined as Level B harassment occurs, and no take of marine mammals occurs. When the water is too shallow for deployment of a bubble curtain, the harassment zones for unattenuated impact pile installation will be monitored (Table 6-16 and Table 6-17).

Level A zones for multiple piles will be used if the time period between installation of successive piles is less than one hour; otherwise, it will be assumed that marine mammals will have traversed past the POA area in a one-hour period, and the Level A zones for a single pile will be implemented and used to assess potential Level A exposures (e.g., the reset time will be one hour). No Level A take for beluga whales has been requested. All Level A take of beluga whales will be avoided, and therefore, resetting the Level A zones between piles, when no beluga whales or marine mammals have been sighted within the Level A zones, does not place marine mammals at risk.

To account for potential variations in daily productivity during impact installation, isopleths were calculated for different numbers of piles that could be installed each day (Table 6-16 and Table 6-17). Should the Contractor expect to install fewer piles in a day than the maximum anticipated, the Level A harassment zones would be smaller. At the beginning of each day, the Contractor will determine how many piles are expected to be installed that day, and the corresponding Level A zones (Table 6-16 and Table 6-17) will be monitored. For example, if the Contractor expects to install three piles using an impact hammer with a bubble curtain, the Level A zones for this installation method, pile size, and number of piles will be monitored. If, after the first pile is installed, no marine mammals have been observed within their respective Level A zones, the zones monitored during installation of the second pile would be those for a two-pile day. Since no marine mammal would have been exposed to noise during the first pile, no marine mammal would experience noise accumulation. Likewise, if no marine mammals have been observed within their respective Level A zones during installation of the second pile, the zones monitored during installation of the third pile would be those for a single-pile day. If a marine mammal is exposed to Level A noise levels, then Level A take will be documented, and the larger zones will continue to be monitored.

It is not anticipated that marine mammals would linger within the Level A zones. Beluga whales swim past the POA on their way to the mouths of the Eagle and Knik rivers and back again. They generally move with the tides and are not known to spend time at the POA, as explained in Section 4.5.5. As explained in Section 2.2.1, tides in Knik Arm are semidiurnal with 24-hour, 50-minute periodicity (which means that low and high tides are about 5.5 to 7 hours apart). Belugas that swim past the POA to the Eagle and Knik rivers and back again could be ensonified only for the brief period of time it would take to swim through a Level A zone, the maximum size of which is 28 meters for 0.7 unattenuated 144-inch pile per day (see Table 6-16). The likely scenario for installation of 144-inch piles is with a bubble curtain, which produces a smaller Level A zone of 11 meters assuming 0.7 pile per day. The likelihood is discountable that a marine mammal could be exposed to Level A sound from more than one pile.

Geographic information system (GIS) software (ArcGIS 10.4.1) was used to map the Level A and Level B harassment isopleths. Land masses near the POA, such as the North Extension, act as barriers to underwater noise and prevent further spread of sound pressure waves. As such, the harassment zones for each threshold were truncated with consideration of these impediments to sound transmission.

The distances to the Level A and Level B isopleths were used to estimate the areas of the Level A and Level B harassment zones. The area of the isopleth is dependent on location of the pile: the closer the pile is to shore, the smaller the harassment zone. Therefore, in order to calculate take in Section 6.4.2, the largest possible area (i.e., the isopleth around the pile farthest from shore) was used and displayed in Table 6-18, Table 6-19, and Figure 6-9 through Figure 6-14. GIS software was used to map the Level A and Level B harassment isopleths for each type of activity at the pile farthest from shore. The measured areas (Table 6-18 and Table 6-19) were then used in take calculations for beluga whales (Section 6.5.5).

Table 6-18. Areas of the Level A and Level B Harassment Zones for Project Components during Phase 1

<table>
<tr><th colspan="3" rowspan="3">Activity</th><th rowspan="3">Piles installed per day</th><th colspan="5">Level A injury zone (km^2)</th><th colspan="5">Level B harassment zone (km^2)</th></tr>
<tr><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th></tr>
<tr><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th></tr>
<tr><td rowspan="6">48” Loading Platform Installation</td><td rowspan="6">Impact</td><td rowspan="3">**Bubble Curtain**</td><td>1</td><td>**0.8**</td><td rowspan="2">**< 0.01**</td><td>**1.1**</td><td>**0.3**</td><td rowspan="3">**< 0.01**</td><td colspan="5" rowspan="3">**0.8**</td></tr>
<tr><td>2</td><td>**1.7**</td><td>**2.3**</td><td>**0.6**</td></tr>
<tr><td>3</td><td>**2.6**</td><td>**0.01**</td><td>**3.5**</td><td>**1**</td></tr>
<tr><td rowspan="3">Unattenuated</td><td>1</td><td>4.6</td><td>0.02</td><td>6.1</td><td>1.7</td><td rowspan="2">< 0.1</td><td colspan="5" rowspan="3">3.7</td></tr>
<tr><td>2</td><td>10.0</td><td>0.05</td><td>13.5</td><td>3.5</td></tr>
<tr><td>3</td><td>15.9</td><td>0.08</td><td>20.8</td><td>5.5</td><td>0.1</td></tr>
<tr><td rowspan="6">48” Access Trestle Installation</td><td rowspan="6">Impact</td><td rowspan="3">**Bubble Curtain**</td><td>1</td><td>**1.1**</td><td rowspan="3">**< 0.01**</td><td>**1.4**</td><td>**0.4**</td><td>**< 0.01**</td><td colspan="5" rowspan="3">**0.7**</td></tr>
<tr><td>2</td><td>**2.3**</td><td>**3.0**</td><td>**0.8**</td><td rowspan="2">**0.02**</td></tr>
<tr><td>3</td><td>**3.5**</td><td>**4.7**</td><td>**1.3**</td></tr>
<tr><td rowspan="3">Unattenuated</td><td>1</td><td>6.2</td><td>< 0.1</td><td>8.3</td><td>2.2</td><td>< 0.1</td><td colspan="5" rowspan="3">3.6</td></tr>
<tr><td>2</td><td>13.5</td><td rowspan="2">0.1</td><td>18.2</td><td>4.7</td><td rowspan="2">0.1</td></tr>
<tr><td>3</td><td>20.9</td><td>26.0</td><td>7.4</td></tr>
<tr><td rowspan="2">48” Loading Platform and Access Trestle Installation</td><td rowspan="2">Vibratory</td><td>**Bubble Curtain**</td><td>1</td><td colspan="5">**< 0.01**</td><td colspan="5">**7.7**</td></tr>
<tr><td>Unattenuated</td><td>1</td><td colspan="5">< 0.01</td><td colspan="5">37.6</td></tr>
<tr><td rowspan="2">36” Temporary Access Work Trestle and Derrick Barge Vibratory Installation and Removal</td><td rowspan="2">Vibratory</td><td>**Bubble Curtain**</td><td rowspan="2">4</td><td colspan="5">**<0.01**</td><td colspan="5">**4.55**</td></tr>
<tr><td>Unattenuated</td><td colspan="5">< 0.01</td><td colspan="5">26.3</td></tr>
<tr><td rowspan="2">36” Temporary Access Work Trestle (restrikes)</td><td rowspan="2">Impact</td><td>**Bubble Curtain**</td><td rowspan="2">3</td><td>**0.02**</td><td>**< 0.01**</td><td>**0.03**</td><td>**0.01**</td><td>**<0.01**</td><td colspan="5">**0.2**</td></tr>
<tr><td>Unattenuated</td><td>0.1</td><td>< 0.01</td><td>0.2</td><td>0.1</td><td>< 0.01</td><td colspan="5">0.9</td></tr>
</table>

Table 6-18. Areas of the Level A and Level B Harassment Zones for Project Components during Phase 1

Activity			**Piles installed per day**	**Level A injury zone (km²)**					**Level B harassment zone (km²)**				
				Cetaceans			**Pinnipeds**		**Cetaceans**			**Pinnipeds**	
				LF	**MF**	**HF**	**PW**	**OW**	**LF**	**MF**	**HF**	**PW**	**OW**
24" Temporary Construction Work Trestle and Access Trestle Template, Installation and Removal, plumb	Vibratory	Bubble Curtain	4	**< 0.01**					**1.3**				
		Unattenuated		< 0.01					7.7				
24" Temporary Dolphins, Installation and Removal, battered	Vibratory	Bubble Curtain	3	< 0.01					1.3				
		Unattenuated		**< 0.01**					**7.7**				
24" Temporary Construct-ion Work Trestle, Access Trestle Template, and Temporary Dolphins Installation and Removal, Plumb	Impact	Bubble Curtain	5	**< 0.1**	**< 0.01**	**< 0.1**	**< 0.01**	**< 0.01**	**0.2**				
		Unattenuated		0.1	< 0.01	0.1	< 0.01	< 0.01	0.8				

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; km²= square kilometers.

Table 6-19. Areas of the Level A and Level B Harassment Zones for Project Components during Phase 2

Activity			**Piles installed per day**	**Level A injury zone (km^2)**					**Level B harassment zone (km^2)**				
				Cetaceans			**Pinnipeds**		**Cetaceans**			**Pinnipeds**	
				LF	**MF**	**HF**	**PW**	**OW**	**LF**	**MF**	**HF**	**PW**	**OW**
144" Breasting and Mooring Dolphin Installation	Impact	Bubble Curtain	0.3	**7.9**	**< 0.1**	**10.7**	**2.8**	**< 0.1**	**6**				
			0.7	**20.4**	**0.1**	**25.5**	**7.2**	**0.1**					
		Unattenuated	0.3	37.5	0.2	45.5	17.1	0.2	28				
			0.7	69.6	0.5	86.9	35.0	0.6					
	Vibratory	Bubble Curtain	1	**< 0.01**					**96**				
		Unattenuated	1	< 0.1	< 0.01	< 0.1	< 0.01		347				
36” Dolphin Template and Temporary Derrick Barge Piles, Vibratory Installation and Removal	Vibratory	**Bubble Curtain**	**4**	**< 0.01**					**4.6**				
		Unattenuated	4	< 0.01					26.3				
24” Temporary Dolphins Vibratory Installation and Removal, plumb	Vibratory	Bubble Curtain	3	**< 0.01**					**1.3**				
		Unattenuated	3	< 0.01					7.7				
24” Temporary Dolphins Vibratory Installation and Removal, battered	Vibratory	Bubble Curtain	3	< 0.01					1.3				
		Unattenuated	3	**< 0.01**					**7.7**				

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; km^2 = square kilometers.

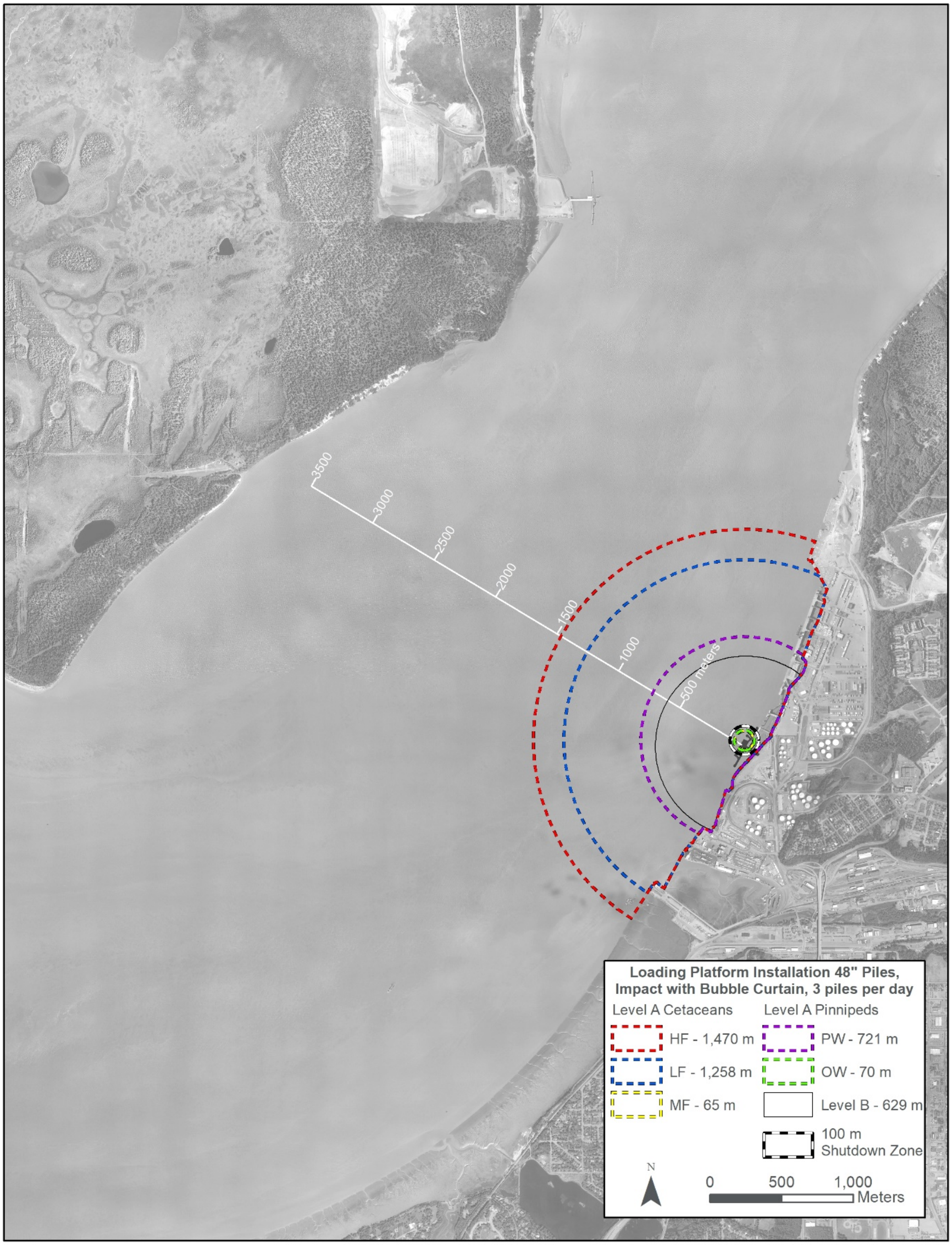

Figure 6-9. Level A and Level B Harassment Isopleths during Phase 1 Impact Installation with a Bubble Curtain of 48-inch Loading Platform Piles at an Installation Rate of Three Piles per Day

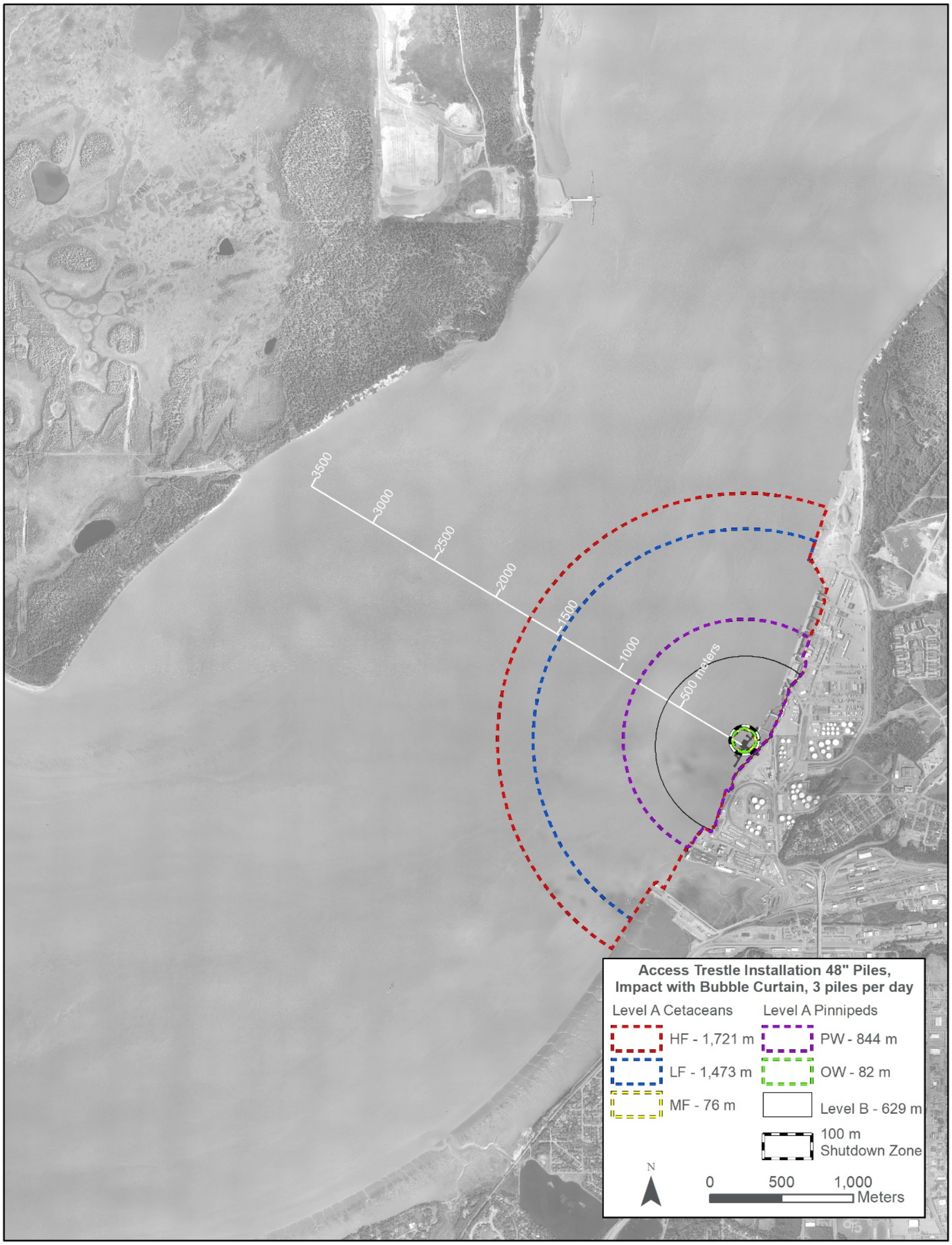

Figure 6-10. Level A and Level B Harassment Isopleths during Phase 1 Impact Installation with a Bubble Curtain of 48-inch Access Trestle Dolphins at an Installation Rate of Three Piles per Day

Figure 6-11. Level B Harassment Isopleths during Impact Installation and Vibratory Installation and Removal of 24-inch Temporary Construction Piles

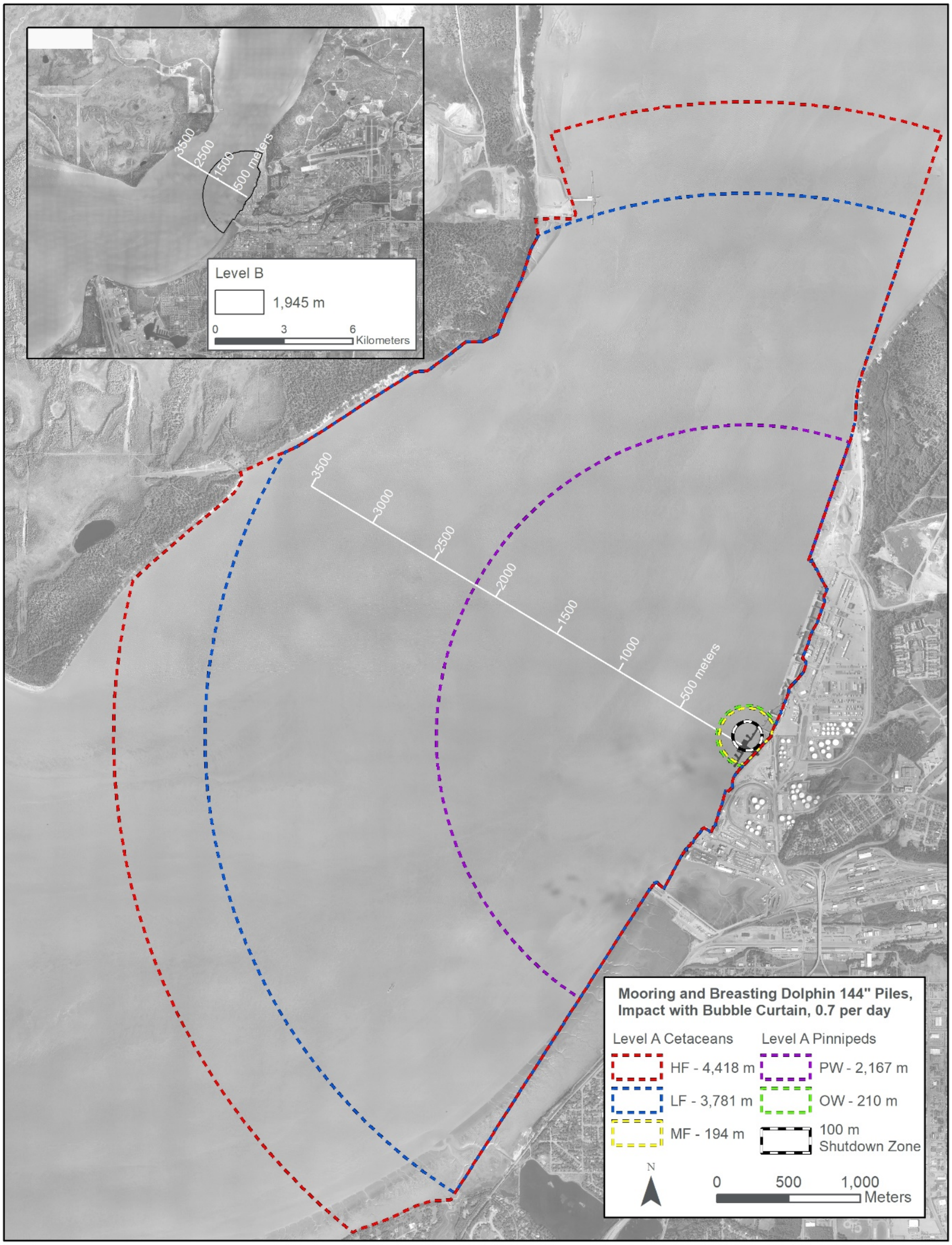

Figure 6-12. Level A and Level B Harassment Isopleths during Phase 2 Impact Installation with a Bubble Curtain of 144-inch Mooring and Breasting Dolphin Piles at an Installation Rate of 0.7 Pile per Day

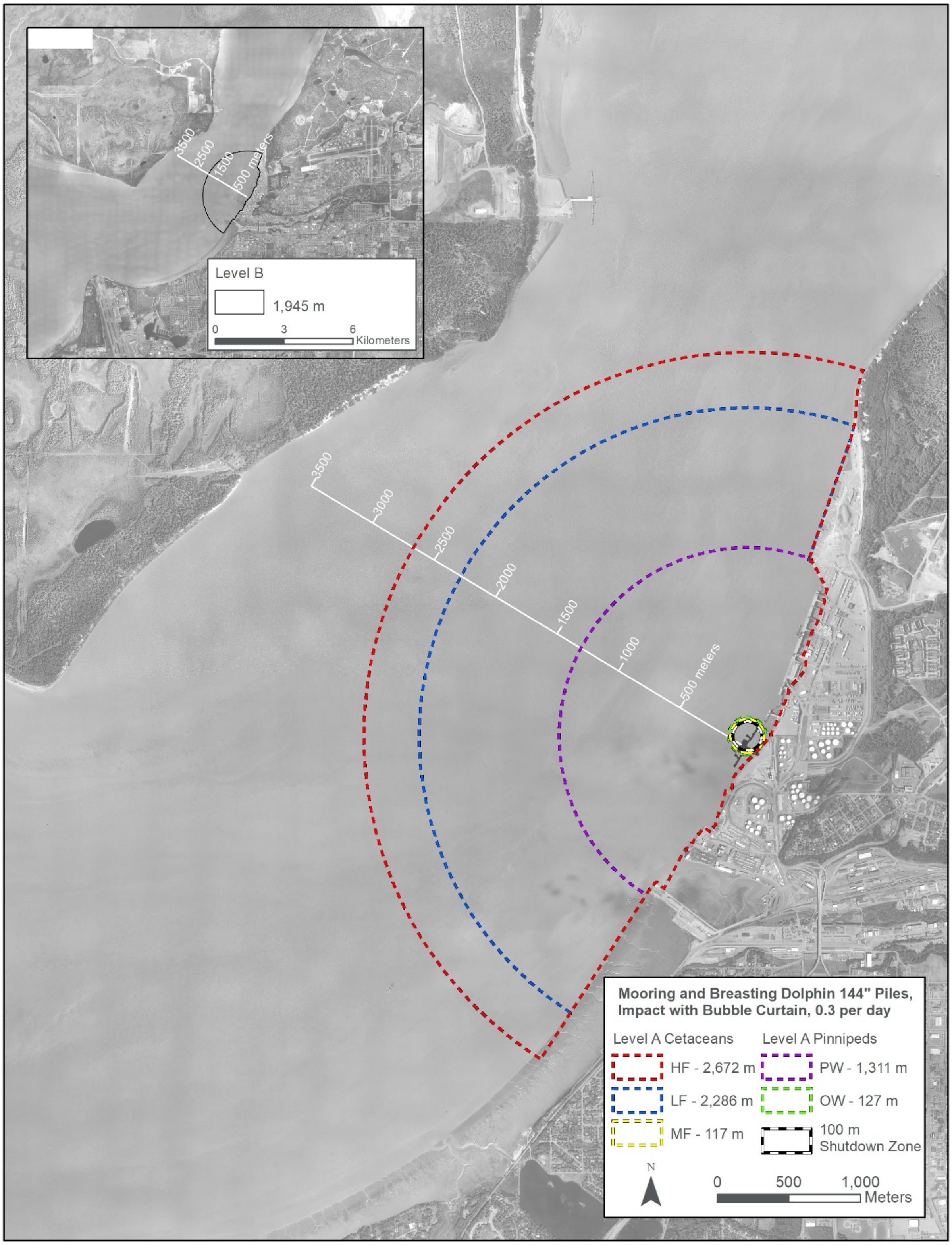

Figure 6-13. Level A and Level B Harassment Isopleths during Phase 2 Impact Installation with a Bubble Curtain of 144-inch Mooring and Breasting Dolphin Piles at an Installation Rate of 0.3 Pile per Day

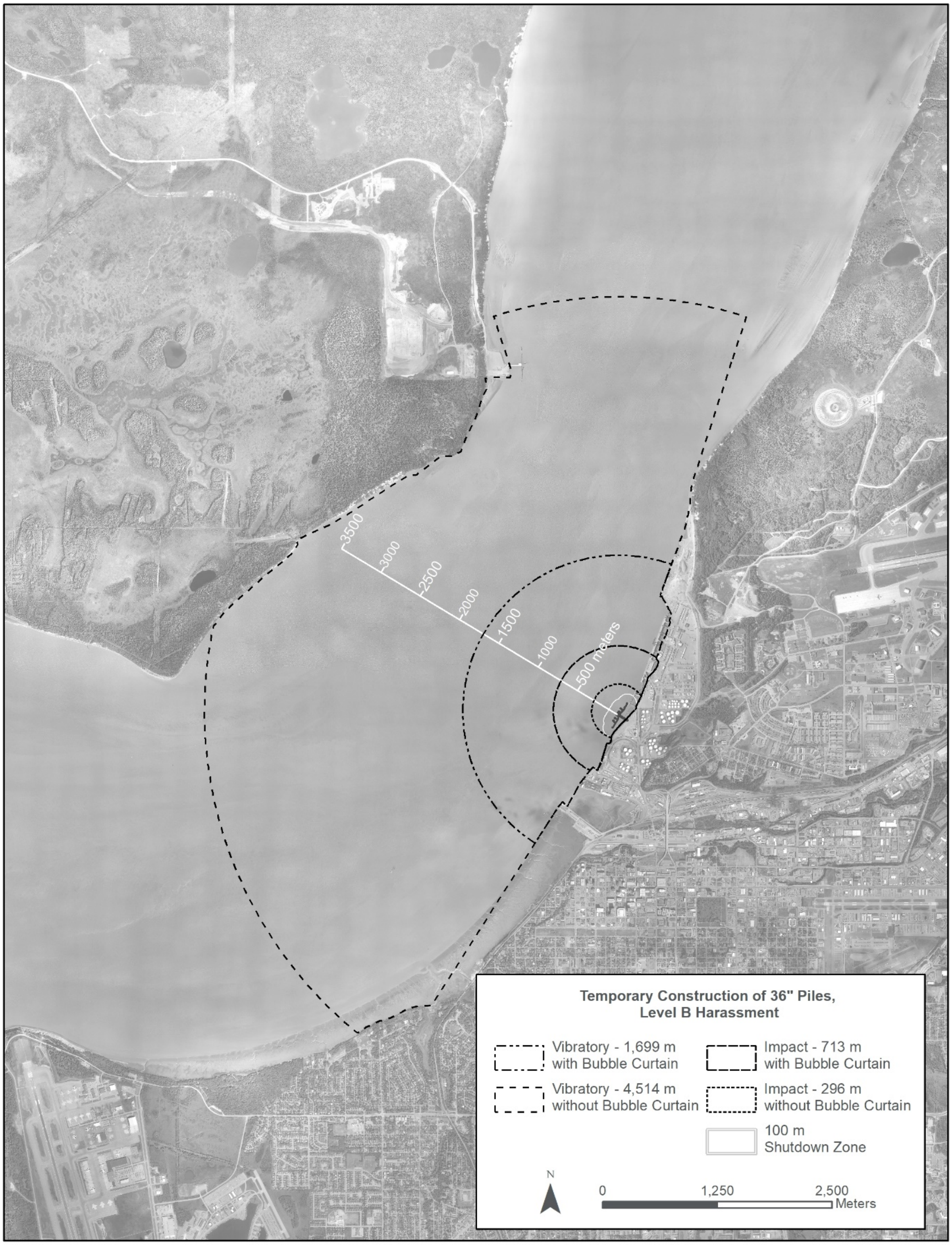

Figure 6-14. Level B Harassment Isopleths during Vibratory Installation and Removal of 36- inch Temporary Construction Piles in Phase 2

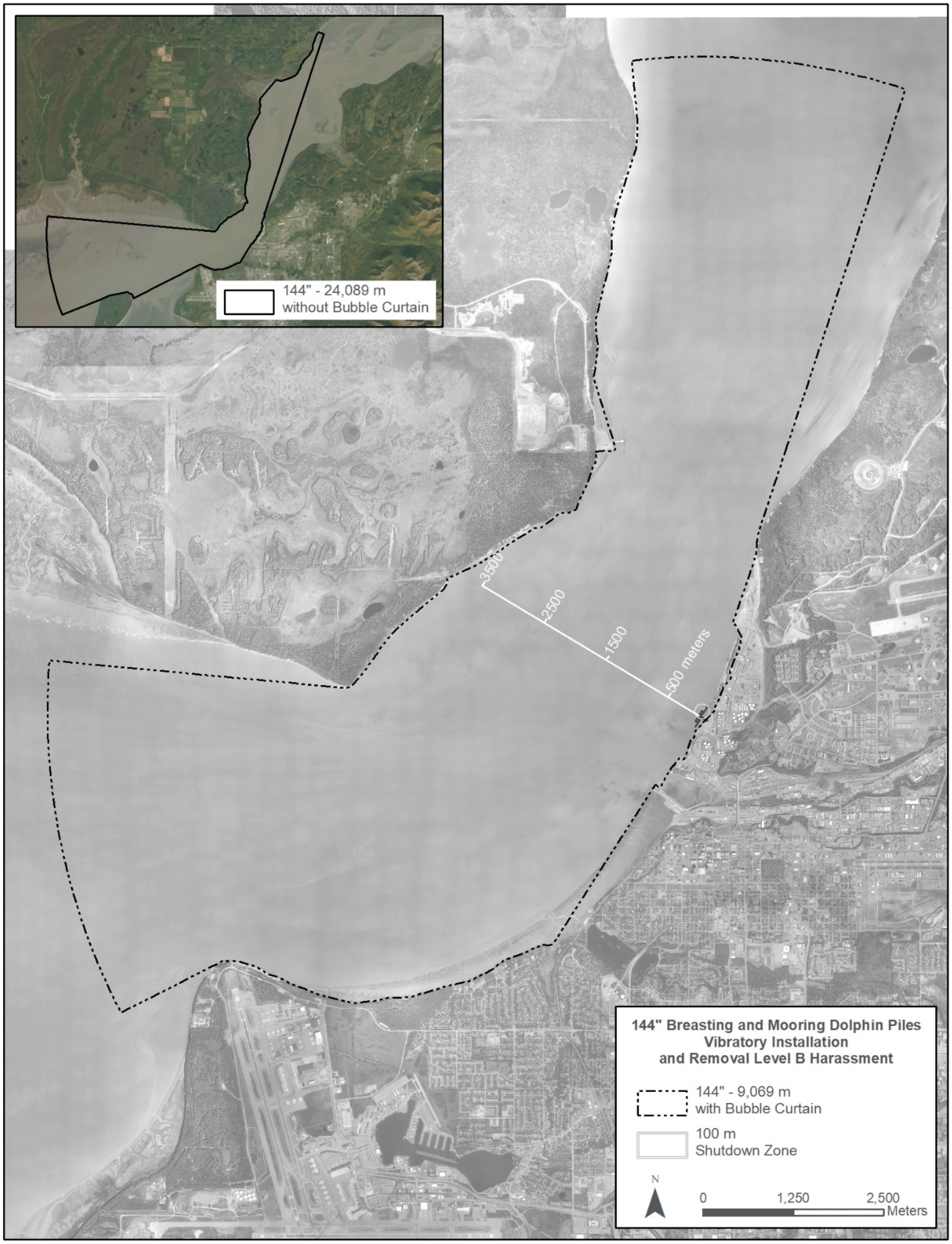

Figure 6-155. Level B Harassment Isopleths during Vibratory Installation and Removal of 144- inch Breasting and Mooring Dolphin Piles in Phase 2

6.4.2 In-air Noise

The spherical spreading model with sound transmission loss of 6.0 dB per doubling distance for a hard surface ($D = D_o * 10^{[(\text{Construction Noise – Ambient Sound Level in dBA})/\alpha]}$; WSDOT 2018 was used to estimate noise threshold distances from the mean source levels. In the model,

D = the distance from the noise source

D_o = the reference measurement distance (15 meters [50 feet] in this case)

α = 20 for hard ground or water, which assumes a 6 dBA reduction per doubling distance

The distance to the in-air sound level threshold for impact installation of 48-inch steel piles is 20 meters for all pinnipeds except harbor seals, and 64 meters for harbor seals (Table 6-20).

Table 6-20. Distances (meters) from Impact Installation where In-air Sound will Attenuate to NMFS Threshold for Level B Harassment

Method, pile type	**Harbor Seals (90 dB)**	**Other Pinnipeds (100 dB)**
Impact Installation (loudest expected sound source level)		
48-inch piles	64	20

Note: dB = decibels; m = meters.

Although in-air noise from installation of 144-inch piles is likely louder than that produced by installation of 48-inch piles, the estimates for distances that in-air noise could travel and exceed the harassment threshold for in-air disturbance fall far short of the distance to the nearest known pinniped haulout (24 to 96 kilometers (15 to 60 miles) south-southwest of Anchorage for harbor seals; Section 4.1.3). Therefore, in-air noise is not considered further for PCT construction, and no incidental take of marine mammals for in-air noise is requested.

6.5 Estimated Numbers Exposed to Noise

6.5.1 Harbor Seals

No known harbor seal haulout or pupping sites occur in the vicinity of the POA; therefore, exposure of harbor seals to in-air noise is not considered in this application, and no take for in-air exposure is requested. Harbor seals are not known to reside in the project area, but they are seen regularly near the mouth of Ship Creek when salmon are running, from July through September. With the exception of newborn pups, all ages and sexes of harbor seals could occur in the project area during construction of the PCT. Any harassment of harbor seals during pile installation would involve a limited number of individuals that may potentially swim through the project area or linger near Ship Creek. Harbor seals that are disturbed by noise may alter their behavior (e.g., modify foraging patterns) and be temporarily displaced from the project area.

Marine mammal monitoring data collected during the MTRP and TPP were used to estimate daily sighting rates for harbor seals in the project area (Table 4-1). Sighting rates of harbor seals were highly variable and sighting rates may have increased during MTRP monitoring between 2005 and 2011 (Table 4-1). It is unknown whether any potential increase was due to local population increases or habituation to ongoing construction activities. The highest individual sighting rate recorded for a previous year was used to quantify take of harbor seals for pile installation associated with the PCT. The number of sightings of harbor seals during 2016 TPP construction monitoring was 28 sightings recorded over 83.5 hours of monitoring from 3 May through 21 June 2016 (Table 4-1). Based on these observations, the sighting rate during the 2016 TPP construction monitoring period was one harbor seal every 3 hours, or approximately four harbor seals per 12-hour work day. Given projected positive population growth, as described in Section 4.4.1, it is anticipated that eight harbor seals may be observed, and potentially exposed to noise, per 12-hour work day.

Estimated exposure to pile installation for all marine mammals except beluga whales is calculated by the following equation:

Exposure estimate = N * # days of pile installation, where:

N = highest daily abundance estimate for each species in project area

Pile installation and removal is anticipated to take approximately 202 days to complete, 127 days for Phase 1 and 75 days for Phase 2, depending on the number of piles installed each day (Table 1-2). Therefore, we estimate that no more than 1,016 harbor seals during Phase 1 (8 harbor seals per day * 127 days) plus 600 harbor seals (8 harbor seals per day * 75 days) during Phase 2, for a total of 1,616 harbor seals, would be potentially exposed to in-water noise levels exceeding the Level B harassment thresholds for pile installation/removal during PCT construction..

All efforts will be taken to shut down prior to a harbor seal entering the 100-meter shutdown zone (Section 11), and prior to a harbor seal entering the Level A harassment zone. However, harbor seals often act curious of onshore activities, and previous monitoring suggests that this species may aggregate at the mouth of Ship Creek. It is important to note that the mouth of Ship Creek is located about 700 meters from the southern end of the PCT, and is therefore located outside the Level A zones for all species and pile sizes during both unattenuated and attenuated (with a bubble curtain) impact and vibratory pile installation. Given the difficulty of detecting the species at great distances and their relative abundance in the area, we are requesting Level A take for a small number of harbor seals. Of the 1,616 harbor seals potentially exposed, we estimate that approximately 30 percent of the total, or 305 harbor seals during Phase 1 and 180 harbor seals during Phase 2, could enter the Level A harassment zone. In total, we estimate approximately 485 harbor seals could be exposed to Level A harassment levels and approximately 1,131 harbor seals could be exposed to Level B harassment levels, for a total of 1,616 potential exposures.

Exposure is anticipated to be further minimized because pile installation/removal would occur intermittently (Table 1-2) over the construction period. Few harbor seals (e.g., no more than eight per day) are expected to approach the project area, and this small number of potential exposures is anticipated to have no measurable effect on the population as a whole.

6.5.2 Steller Sea Lions

Steller sea lions are anticipated to be encountered in low numbers, if at all, within the project area (Section 4.2.4). Three sightings of what was likely a single individual occurred in the project area in 2009 and two sightings occurred in 2016. Based on observations in 2016, we anticipate an exposure rate of 2 individuals every 19 days during PCT pile installation and removal. Based on this rate, we anticipate up to 21 exposures of Steller sea lions could occur during PCT pile installation and removal. This includes 13 sea lions during Phase 1 (127 days / [2 sea lions every 19 days] = 13 sea lions [rounded down] plus 8 sea lions during Phase 2 (75 days for Phase 2 / [2 sea lions every 19 days] = 8 sea lions [rounded up]).

All efforts will be taken to shut down prior to a sea lion entering the 100-meter shutdown zone (Section 11), and prior to a sea lion entering the Level A harassment zone. However, sea lions are known to travel at high speeds and in rapidly changing directions. It is possible that, despite all precautions, sea lions could enter the Level A harassment zone before a shutdown could be fully implemented. During PCT construction, we anticipate that of the 21 sea lions potentially exposed to underwater noise from pile installation, approximately 30 percent or 4 individuals could be exposed to Level A harassment levels during Phase 1, and 2 could be exposed to Level A harassment during Phase 2. Therefore, the POA requests Level B harassment take of 15 Steller sea lions and Level A harassment take of an additional 6 Steller sea lions.

6.5.3 Harbor Porpoises

Aerial surveys to estimate population size for the Cook Inlet stock of harbor porpoises were conducted between 09 and 15 June 1998. The surveys yielded an average harbor porpoise density in Cook Inlet of 0.013 harbor porpoises/km^2 (Hobbs and Waite 2010). Although the surveys transited both upper and lower Cook Inlet, harbor porpoise sightings were limited to eight, all of which were south of Tuxedni Bay, in lower Cook Inlet; no harbor porpoises were sighted during this survey in upper Cook Inlet. Given the timing of this survey effort and lack of upper Cook Inlet sightings, use of this density for estimating take of harbor porpoises in association with the PCT Project, which is planned for multiple months, would not be appropriate.

Monitoring data recorded for the MTRP and TPP were used to evaluate daily sighting rates for harbor porpoises in the project area (Table 4-2). During most years of monitoring, no harbor porpoises were observed. However, there has been an increase in harbor porpoise sightings in upper Cook Inlet over the past 2 decades (Shelden et al. 2014). The highest individual sighting rate for any recorded year during pile installation and removal associated with the PCT was an average of 0.09 harbor porpoises per day during 2009 construction monitoring, but this value does not account for increases in population size or range extensions. Therefore, it is assumed that one harbor porpoise could be observed every 2 days. We estimate that approximately 102 harbor porpoises could be exposed to harassment over the course of PCT pile installation and removal. This includes 64 exposures during Phase 1 (127 days / [1 harbor porpoise every 2 days] = 64 harbor porpoises [rounded up]) and 38 harbor porpoises during Phase 2 (75 days for Phase 2 / [1 harbor porpoise every 2 days] = 38 harbor porpoises [rounded up]). This precautionary approach also covers the possibility that larger groups of harbor porpoises could occur less frequently.

All efforts will be taken to shut down prior to a harbor porpoise entering the Level A harassment zone or 100-meter shutdown zone (Section 11). During impact installation of 48-inch piles, the Level A harassment isopleth for high-frequency cetaceans (e.g., harbor porpoises) extends 164 meters (assuming optimal productivity of three access trestle piles installed per day; Table 6-16 and Figure 6-4). Harbor porpoises are relatively small cetaceans that move at high velocities, which can make their detection and identification at great distances difficult. Therefore, the potential exists that a small number of harbor porpoises could enter the Level A harassment zone undetected. Of the 102 harbor porpoises potentially exposed, we estimate that approximately 31 individuals (30 percent of the total potential exposures) could enter the Level A harassment threshold, 20 during Phase 1 and 11 during Phase 2. In total, we estimate approximately 31 harbor porpoises could be exposed to Level A harassment levels and approximately 71 harbor porpoises could be exposed to Level B harassment levels.

With in-water pile installation and removal occurring intermittently over the construction period, the potential for exposure within the Level B harassment isopleths is anticipated to be low. Few harbor porpoises are expected to approach the project area, and the small number of takes requested is expected to have a negligible effect on individual animals and no measurable effect on the population as a whole.

6.5.4 Killer Whales

Numbers of resident and transient killer whales in upper Cook Inlet are very small in comparison with their overall population sizes. Few, if any, killer whales are expected to approach the project area. No killer whales were sighted during previous monitoring programs for the Knik Arm Crossing and POA construction projects, including the 2016 TPP (Cornick and Pinney 2011; Cornick and Seagars 2016;

Cornick and Saxon-Kendall 2008, 2009; Cornick et al. 2010, 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). The infrequent sightings of killer whales that are reported in upper Cook Inlet tend to occur when their primary prey (anadromous fish for resident killer whales and beluga whales for transient killer whales) are also in the area (Shelden et al. 2003). Previous sightings of transient killer whales have documented pod sizes in upper Cook Inlet between one and six individuals (Shelden et al. 2003).

The potential for exposure of killer whales within the Level B harassment isopleths is anticipated to be extremely low. Level B take is conservatively estimated at no more than 2 small pods (12 individuals) during Phase 1 and one small pod (6 individuals) during Phase 2, for a total of 18 killer whales, or three small pods (range of 1 to 6 individuals; Shelden et al. (2003), Section 4.4.3), for the duration of pile installation and removal. Few killer whales are expected to approach the project area, and this small potential exposure is expected to have a negligible effect on an individual animal and no effect on killer whale populations as a whole. No Level A take for killer whales is anticipated or requested under this authorization considering the proposed 100-meter shutdown zone.

6.5.5 Beluga Whales

Potential exposure of beluga whales to pile installation and removal was calculated differently than for other marine mammals because predicted density data are available for this species (Goetz et al. 2012a). The numbers of beluga whales potentially exposed to noise levels above the Level B harassment threshold for pile installation and removal were estimated using the following formula:

Beluga Exposure Estimate = N * Area * number of days of pile installation/removal, where:

N = maximum predicted # of beluga whales/km^2 based on data from Goetz et al. (2012a)

Area = Area of Level B Isopleth (km^2; see Table 6-18)

Cook Inlet beluga whale densities were derived from aerial surveys completed primarily in June from 1994 through 2008 (Goetz et al. 2012a). Data from these aerial surveys were used along with depth soundings, coastal substrate type, an environmental sensitivity index, an index of anthropogenic disturbance, and information on anadromous fish streams to develop a predictive beluga whale habitat model (Goetz et al. 2012a). Three different beluga distribution maps were produced from the habitat model based on sightings of beluga whales during aerial surveys. First, the probability of beluga whale presence was mapped using a binomial (i.e., yes or no) distribution and the results ranged from 0.00 to 0.01. Essentially, this means that there is no more than a 1 percent chance of a beluga whale being present in any portion of Cook Inlet at any time. Second, the expected group size was mapped. Group size followed a Poisson distribution, which ranged from 1 to 231 individuals in a group. Third, the product (i.e., multiplication) of these predictive models produced an expected density model, with beluga whale densities ranging from 0 to 1.12 beluga whales/km^2. From this model, Goetz et al. (2012a) developed a raster GIS dataset that provides a predicted density of beluga whales throughout Cook Inlet at a scale of 1 km^2 (Figure 6-15). As discussed below, the model output is based on data collected primarily in June, which is a known period of low abundance in Knik Arm, but it is the best available density data for beluga whales in upper Cook Inlet and is the dataset preferred by NMFS for use in beluga exposure estimates. In fact, in their recently finalized *Recovery Plan for the Cook Inlet Beluga Whale*, NMFS (2016) stated that the distribution presented by Goetz et al. (2012a) is “largely representative of the distribution throughout the ice-free months.”

The predicted beluga whale density raster (Figure 6-15) was overlaid with the Level B isopleths for each size of pile and method of installation to determine the maximum predicted beluga whale density for that configuration (pile size, installation method, and use of sound attenuation system). The maximum beluga whale densities within the Level B isopleths ranged from 0.042 to 0.236 beluga whales/km^2. It was noted, however, that beluga whale densities in upper Knik Arm, at 0.291 beluga whales/km^2, were higher than the densities within the ensonified areas around the POA. Logically, beluga whales that were detected in upper Knik Arm during aerial surveys must have swum up Knik Arm past the POA, likely that same day during the preceding incoming tide (Section 4.5.5). The aerial survey data represent a snapshot in time, and since beluga whales are known to swim relatively quickly past the POA on their way to foraging areas in upper Knik Arm, where they linger to feed, they were more likely to be documented in that area than near the POA. It was assumed, therefore, that the highest density estimate from upper Knik Arm was a reasonable representation of maximum beluga whale density at the POA. This density was then multiplied by the area of each isopleth for each pile installation configuration (Table 6-21). As described in Section 1.3.1, bubble curtain attenuation systems will be used during installation and removal of plumb piles. However, it is anticipated that bubble curtains will not be used during installation of battered piles and may not be used on approximately 10 percent of plumb piles, and our exposure estimate takes into consideration these assumptions (Table 6-21). Based on predicted beluga whale densities, an estimated total of 228 beluga whales could be exposed to noise levels at the Level B harassment level during impact pile installation and vibratory installation and removal. The 228 individual exposures were derived by summing the exposure estimates for each configuration, which resulted in an estimate of 227.87, rounded up to 228 whales, during construction of the PCT (Table 6-21). However, **the POA only requests a total of 114 takes over 2 years, 56 takes of beluga whales for Phase 1, and 58 takes of beluga whales for Phase 2 (see further discussion below).**

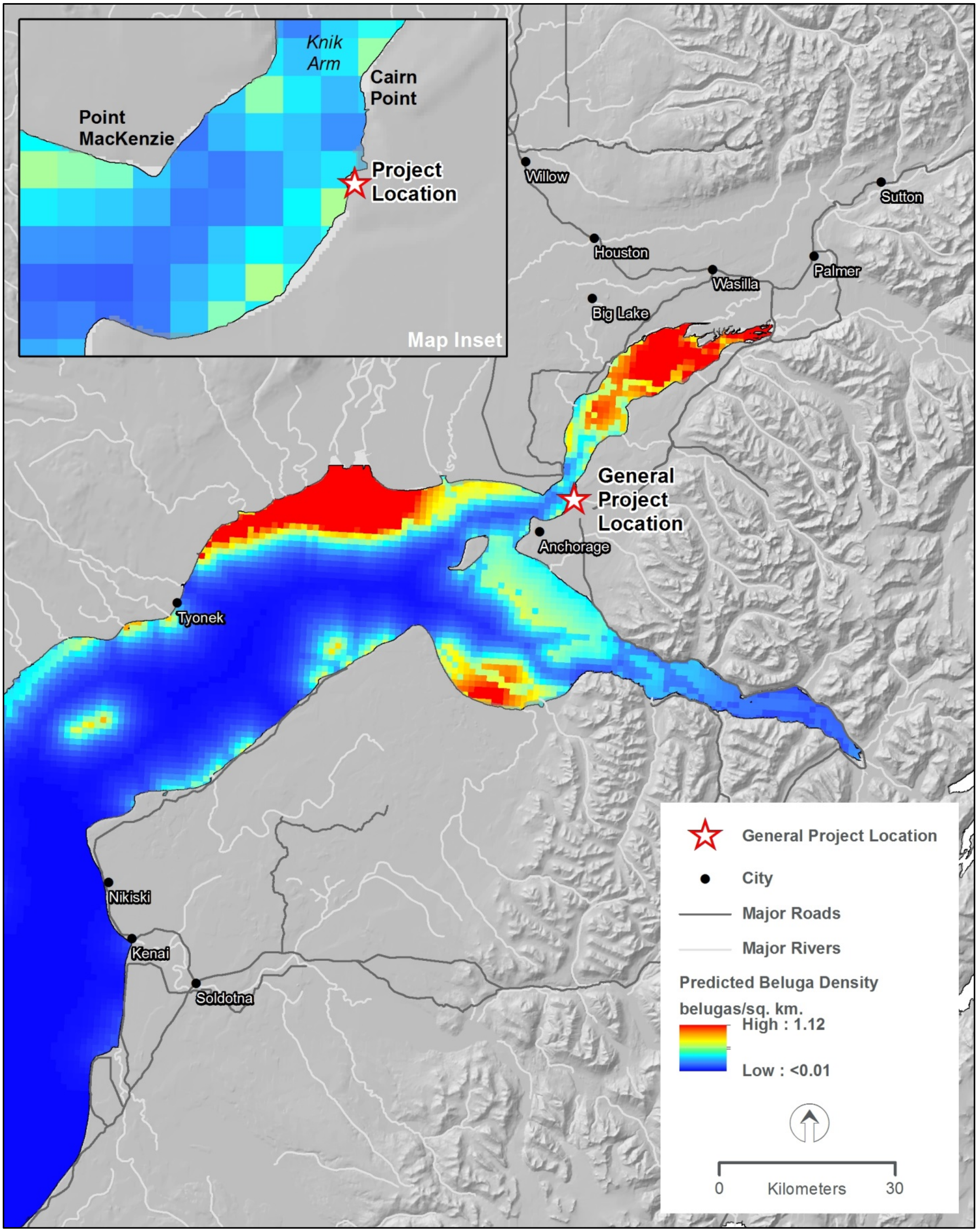

Figure 6-16. Predicted Beluga Whale Densities within Upper Cook Inlet Based on Goetz et al. 2012a Geospatial Data

Table 6-21. Beluga Whale Exposure Estimates for Each PCT Pile Size and Method of Installation and Removal

Activity		# of Days to Install Piles	Maximum Beluga Density (# / km²)	Maximum Area of Isopleth (km²)	Predicted Number of Beluga Whales within Isopleth[a]	Exposure Estimate[b]
Phase 1						
48" Platform and Access Trestle Impact Installation	**Bubble Curtain**	40	**0.291**	**0.75**	**0.22**	**8.73**
	Unattenuated		0.291	3.68	1.07	42.84
48" Platform and Access Trestle Vibratory Installation	**Bubble Curtain**	7	**0.291**	**7.7**	**2.24**	**15.68**
	Unattenuated		0.291	37.62	10.95	76.63
36" Work Trestle, Plumb Vibratory Installation/Removal	**Bubble Curtain**	18	**0.291**	**4.55**	**1.32**	**23.83**
	Unattenuated		0.291	26.3	7.65	137.76
36" Temporary Barge Mooring Piles Vibratory Installation/Removal	**Bubble Curtain**	2	**0.291**	**4.55**	**1.32**	**2.65**
	Unattenuated		0.291	26.3	7.65	15.31
24" Work Trestle, Plumb Vibratory Installation/ Removal	**Bubble Curtain**	18	**0.291**	**1.28**	**0.37**	**6.70**
	Unattenuated		**0.291**	**7.71**	**2.24**	**40.38**
24" Work Trestle, Battered Vibratory Installation/ Removal	Bubble Curtain	12	0.291	1.28	0.37	4.47
	Unattenuated		**0.291**	**7.71**	**2.24**	**26.92**
24" Access Trestle Template, Plumb Vibratory Installation/ Removal	**Bubble Curtain**	24	**0.291**	**1.28**	**0.37**	**8.94**
	Unattenuated		0.291	7.71	2.24	53.85
24" Mooring Dolphins, Plumb Vibratory Installation/ Removal	**Bubble Curtain**	2	**0.291**	**1.28**	**0.37**	**0.74**
	Unattenuated		0.291	7.71	2.24	4.49
24" Mooring Dolphins Battered Vibratory Installation/ Removal	Bubble Curtain	4	0.291	1.28	0.37	1.49
	Unattenuated		**0.291**	**7.71**	**2.24**	**8.97**
Phase 1 Exposure Estimate						**103.18**
Phase 2						
144" Dolphin Impact Installation	**Bubble Curtain**	18	**0.291**	**5.84**	**1.70**	**30.59**
	Unattenuated		0.291	27.54	8.01	144.25

Table 6-21. Beluga Whale Exposure Estimates for Each PCT Pile Size and Method of Installation and Removal

Activity		**# of Days to Install Piles**	**Maximum Beluga Density (# / km²)**	**Maximum Area of Isopleth (km²)**	**Predicted Number of Beluga Whales within Isopleth[a]**	**Exposure Estimate[b]**
144” Dolphin Vibratory Installation	**Bubble Curtain**	1	**0.291**	**62.48**	**18.18**	**18.18**
	Unattenuated		0.291	233.42	67.93	67.93
36” Dolphin Template Vibratory Installation/Removal	**Bubble Curtain**	48	**0.291**	**4.55**	**1.32**	**63.55**
	Unattenuated		0.291	26.3	7.65	367.36
36" Temporary Barge Mooring Piles Vibratory Installation/Removal	**Bubble Curtain**	2	**0.291**	**4.55**	1.32	**2.65**
	Unattenuated		0.291	26.3	7.65	15.31
24” Mooring Dolphins, Plumb Vibratory Installation/ Removal	**Bubble Curtain**	2	**0.291**	**1.28**	**0.37**	**0.74**
	Unattenuated		0.291	7.71	2.24	4.49
24” Mooring Dolphins Battered Vibratory Installation/ Removal	Bubble Curtain	4	0.291	1.28	0.37	1.49
	Unattenuated		**0.291**	**7.71**	**2.24**	**8.97**
Phase 2 Exposure Estimate						**124.69**
					All Bubble Curtain	190.45
					No Bubble Curtain	1015.46
						Total Exposures 228

Note: Bold text corresponds to most likely construction scenario.

It is important to note that the Goetz et al. (2012a) dataset creates an estimated density distribution that both moderates and redistributes actual beluga whale densities. Beluga whale distribution in Cook Inlet is much more clumped than is portrayed by the estimated density model, which dilutes the influence of group size by multiplying by the probability of presence (Figure 6-8). Furthermore, these data represent observations primarily in June, which is only a subset of the proposed PCT construction period. However, NMFS (2016) stated that “the distribution documented in June is largely representative of the distribution throughout the ice-free months.” Beluga whales are highly mobile animals that move based on tidal fluctuations, prey abundance, season, and other factors. Generally, beluga whales pass through the vicinity of the POA to reach high-quality feeding areas in upper Knik Arm or at the mouth of the Susitna River, where they spend more time and are therefore more likely to be detected during aerial surveys. Although beluga whales may occasionally linger in the vicinity of the POA, they typically transit through the area, and are less likely to be detected during aerial surveys. It is important to note that the instantaneous probability of observing a beluga whale at any given time in any area is extremely low (less than 1 percent) based on the Goetz et al. (2012a) model; however, the probability of observing a beluga whale can change drastically and increase well above predicted values based on season, prey abundance, tide stage, and other variables. The Goetz et al. (2012a) density model is limited in its ability to accurately predict beluga group sizes at the POA, and likely underestimates density, which supports use of the highest density value from upper Knik Arm. The exposure estimate presented here is conservative and accounts for the number of beluga whales that may travel past the POA north to the vicinity of the Knik and Eagle rivers.

During previous POA monitoring, large groups of beluga whales were seen swimming through the POA vicinity. Based on reported takes in monitoring reports from 2008 through 2011 and 2016, groups of beluga whales were occasionally taken by Level B harassment during previous POA activities (Table 6-22). Beluga whales were reported as take when animals entered the Level B harassment zone during vibratory hammer installation. On the only occasion when impact hammer pile installation was taking place when beluga whales were taken, vibratory hammer pile installation was also taking place (Table 6-22). The animals did not appear to avoid areas ensonified to the 120-dB level during the continuous sound of vibratory hammer pile installation, and willingly swam into the Level B harassment zone. No changes in behavior were detected.

Table 6-22. Summary of Beluga Whale Takes by the MTRP from 2008 through 2011 and TPP in 2016

Year	Day	Reported Take	Group Composition[b]	Construction Activity	Behavior/Reaction
2008	October 1	3	3 adults	Vibratory pile driving	Behavior: traveling north as a cohesive group Reaction: no observable reaction
	November 7	5	5 adults	Vibratory pile driving	Behavior: swimming south and did not change course Reaction: no observable reaction
2009	May 5	2	1 adult 1 juvenile	Vibratory pile driving	Behavior: diving Reaction: no observable reaction
	May 8	2	1 adult 1 calf	Vibratory pile driving	Behavior: slow traveling Reaction: no observable reaction
	August 7	3	1 white 1 gray 1 dark gray	Vibratory & impact pile driving	Behavior: traveling, swimming, milling, and feeding suspected Reaction: no observable reaction
	September 14	1	1 white	Vibratory pile driving	Behavior: swimming, diving, feeding suspected Reaction: no observable reaction
	October 9	1	1 gray	Vibratory pile driving	Behavior: traveling, diving, milling Reaction: no observable reaction
	November 4	15	6 white 8 gray 1 dark gray	Vibratory pile driving	Behavior: traveling, swimming Reaction: no observable reaction
2010	October 11	5[a]	1 white 3 gray 3 dark gray	Vibratory pile driving	Behavior: traveling, diving, milling Reaction: no observable reaction
	October 26	4[a]	1 white 4 gray 1 dark gray	Vibratory pile driving	Behavior: traveling, swimming, milling, diving Reaction: no observable reaction
2011	September 18	4[a]	7 gray 2 dark gray	Vibratory pile driving	Behavior: traveling, diving, milling Reaction: no observable reaction

Table 6-22. Summary of Beluga Whale Takes by the MTRP from 2008 through 2011 and TPP in 2016

Year	Day	Reported Take	Group Composition[b]	Construction Activity	Behavior/Reaction
2016	May 25	1	1 gray	Vibratory pile driving	Behavior: traveling Reaction: no observable reaction

[a] The entire group did not enter the harassment zone before shutdown occurred; therefore, the total number of individuals in the group does not equal the number of takes.

[b] Generally, adult beluga whales are white, while juveniles are gray, but there are some exceptions.

Source: ICRC 2009a, 2009b, 2009d, 2009e, 2010a, 2010b, 2011a, 2011b, 2012; Cornick and Seagars 2016.

Sometimes beluga whales were initially observed when they surfaced within the harassment zone. For example, on 4 November 2009, 15 whales were initially sighted approximately 950 meters north of the POA near the shore when they surfaced in the Level B harassment zone during vibratory pile installation (ICRC 2009b). Pile installation was immediately shut down, but the 15 whales were documented as takes. On other occasions, beluga whales were initially sighted outside the harassment zone and shutdown was called, but the beluga whales swam into the harassment zone before pile driving could be halted, and take occurred. For example, on 14 September 2009, a construction observer sighted a white beluga whale "just outside the harassment zone, moving quickly towards the 1,300-meter zone" during vibratory pile driving. The animal entered the harassment zone before pile driving could be shut down, and was documented as a take (ICRC 2009c).

The POA intends to implement a rigorous monitoring program during all pile installation and removal in an effort to minimize take and reduce impacts on the animals. However, it is clear that during past monitoring efforts, groups of animals were taken together (Table 6-22). The use of the beluga whale exposure estimate formula alone does not account for larger groups of beluga whales that could be taken.

The total number of calculated exposures or takes of Cook Inlet beluga whales is 228 (Table 6-21). It is not anticipated that all of the calculated takes will occur; the avoidance measures implemented by the POA (Section 11) will reduce the number of beluga whales exposed to project-related noise by an unknown amount. For all anticipated pile sizes and installation methods, the POA's commitment to using a bubble curtain means that noise levels along the western side of Knik Arm will remain below the regulatory thresholds, providing a travel corridor for beluga whales to access upper Knik Arm (see Figures 6-9 through 6-14). Further, for the majority of PCT construction and pile installation and removal, only approximately half of the width of Knik Arm, along the eastern shore, would be ensonified. The largest attenuated Level B isopleth that spans the width of Knik Arm occurs during vibratory installation of 144-inch piles, is anticipated to occur for 10% of the 9 piles (or 1 pile) for approximately 45 minutes, and only when there is an obstruction, safety or constructability issue. Some individuals will preferentially travel north and south along the western shore of Knik Arm (Goetz et al. (2012a). Other individuals may intentionally avoid exposure to project-related and non-project-related noise (see Section 9.1) and use the western shore of Knik Arm as well. According to Funk et al. (2005), beluga whales are not uniformly distributed throughout Knik Arm and use of this area is highly seasonal. Groups of beluga whales seen in the middle portion of Knik Arm were usually moving directionally to the north and east toward the upper portion of Knik Arm during flood tides and directionally south and west during the ebb tide (Funk et al. 2005). Beluga whales are most often spotted in Knik Arm during the late summer and throughout the fall. Beluga whales observed in Knik Arm during the autumn were most frequently sighted on the western side of the arm (Funk et al. 2005). Though there are beluga whales in Knik Arm year-round, sightings are much lower in winter through early summer which further reduces the likelihood that beluga whales could be exposed to project-related noise. Furthermore, it is anticipated that some individuals may be exposed to project noise more than once, reducing the number of affected individuals to small numbers. **In consideration of these factors, the total number of requested takes has been reduced by half. The POA only requests a total of 114 takes over 2 years, 56 takes of beluga whales for Phase 1, and 58 takes of beluga whales for Phase 2.**

No Level A take of beluga whales is requested for this project due to the highly endangered status of this species.

6.5.6 Humpback Whales

Sightings of humpback whales in the project area are rare, and the potential risk of exposure of a humpback whale to sounds exceeding the Level B harassment threshold is low. Few, if any, humpback whales are expected to approach the project area. However, based on two sightings in 2017 of what was likely a single individual at the Ship Creek Boat Launch (ABR 2017) south of the project area, we anticipate exposure of up to 13 individuals for the duration of PCT pile installation and removal. This is based on an observation rate during the Ship Creek Boat Launch project of 1 individual over 16 days of monitoring (127 days for Phase 1 / [1 humpback whale every 16 days] = 8 humpback whales [rounded up] plus 75 days for Phase 2 / [1 humpback whale every 16 days] = 5 humpback whales [rounded up] = 13 humpback whales). This could include sighting a cow-calf pair on multiple days or multiple sightings of single humpback whales. This small potential exposure is expected to have a negligible effect on an individual animal and no effect on humpback whale populations as a whole. No Level A take for humpback whales is anticipated or requested under this authorization.

6.6 All Marine Mammal Takes Requested

The analysis of pile installation and removal associated with the PCT Project predicts potential exposures of marine mammals to noise from pile installation and removal that could be classified as Level A and Level B harassment under the MMPA (Table 6-23). No Level A take is requested for killer whales, beluga whales, or humpback whales.

Table 6-23. Summary of the Estimated Numbers of Marine Mammals Potentially Exposed to Level A and Level B Harassment Noise Levels during Phase 1 and Phase 2

Species	Level A Exposures	Level B Exposures	Species Total	Stock/DPS	Abundance	Percent of Population[a]
			Phase 1			
Harbor seal	305	711	**1,016**	Gulf of Alaska	27,386	3.7
Steller sea lion	4	9	**13**	Western DPS	50,983	<0.1
Harbor porpoise	20	44	**64**	Cook Inlet / Shelikof Strait	31,046	0.2
Killer whale	0	12	**12**	Resident Transient	2,347 587	0.5[b] or 2.0[b]
Beluga whale	0	56	**56**	Cook Inlet	327	17.1
Humpback whale	0	8	**8**	Hawaii DPS Mexico DPS W N Pacific DPS	11,398 3,264 1,059	<0.1[b] or 0.2[b] or 0.8[b]
Phase 1 Totals	**329**	**840**	**1,169**			
			Phase 2			
Harbor seal	180	420	**600**	Gulf of Alaska	27,386	2.2
Steller sea lion	2	6	**8**	Western DPS	50,983	<0.1
Harbor porpoise	11	27	**38**	Cook Inlet / Shelikof Strait	31,046	0.1
Killer whale	0	6	**6**	Resident Transient	2,347 587	0.3[b] or 1.0[b]
Beluga whale	0	58	**58**	Cook Inlet	327	17.7
Humpback whale	0	5	**5**	Hawaii DPS Mexico DPS W N Pacific DPS	11,398 3,264 1,059	<0.1[b] or 0.2[b] or 0.5[b]
Phase 2 Totals	193	522	**715**			
PCT Project Totals	522	1,362	**1,884**			

[a] Population estimates used in calculations are presented in Section 4.

[b] These percentages assume that all potential exposures come from each stock; thus, the percentage should be adjusted down if multiple stocks are actually affected.

Note: NA = not applicable; DPS = distinct population segment.

7 Description of Potential Impacts to Marine Mammals

Marine mammals use hearing and sound transmission to perform vital life functions. Sound (hearing, vocalization, and echolocation) serves four primary functions for marine mammals: (1) providing information about their environment; (2) communication; (3) prey detection; and (4) predator detection. The distances to which pile installation noise from the construction of the PCT Project is audible will depend upon source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al. 1995). In-water pile installation and removal will temporarily increase the local underwater and in-air noise environment in the vicinity of the construction of the PCT Project.

Research suggests that increased noise may impact marine mammals in several ways (e.g., behaviorally and physiologically). The effects of pile installation and removal on marine mammals are dependent on several factors, including the size, type, and depth of the animal; the depth, intensity, and duration of the pile-driving sound; the depth of the water column; the substrate of the habitat; the distance between the pile and the animal; and the sound propagation properties of the environment.

7.1 Zones of Noise Influence

The effects of sounds from pile installation on marine mammals might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment, and non-auditory physical effects (Richardson et al. 1995). In assessing potential effects of noise, Richardson et al. (1995) have suggested four criteria for defining zones of influence. These zones are described below from greatest influence to least:

Zone of hearing loss, discomfort, or injury – the area within which the received sound level is potentially high enough to cause discomfort or tissue damage to auditory or other systems. This includes PTS (loss in hearing at specific frequencies or deafness). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage.

Zone of masking – the area within which the noise may interfere with detection of other sounds, including communication calls, prey sounds, or other environmental sounds.

Zone of responsiveness – the area within which the animal reacts behaviorally or physiologically. The behavioral responses of marine mammals to sound are dependent upon a number of factors, including (1) acoustic characteristics of the noise source of interest; (2) physical and behavioral state of animals at time of exposure; (3) ambient acoustic and ecological characteristics of the environment; and (4) context of the sound (e.g., whether it sounds similar to a predator; Richardson et al. 1995; Southall et al. 2007). However, temporary behavioral effects are often simply evidence that an animal has heard a sound and may not indicate lasting consequence for exposed individuals (Southall et al. 2007).

Zone of audibility – the area within which the marine mammal might hear the noise. Marine mammals as a group have functional hearing ranges of 7 Hz to 180 kHz, with best thresholds near 40 dB (Ketten 1998; NMFS 2018a; Southall et al. 2007). Hearing capabilities of the species included in this application are discussed in Section 4. There are no applicable criteria for the zone of audibility due to difficulties in human ability to determine the audibility of a particular noise for a particular species. This audibility zone does not fall in the sound range of a "take" as defined by NMFS.

7.2 Assessment of Acoustic Impacts

The exposure to noise from pile installation and removal could result in behavioral and mild physiological changes in marine mammals. Some age and sex classes are more sensitive to noise disturbance, and such disturbance may be more detrimental to young animals (e.g., National Research Council 2003). David (2006) suggested that pile installation operations should be avoided when bottlenose dolphins (*Tursiops truncatus*) are calving, since lactating females and young calves are likely to be particularly vulnerable to such sound. Distinct mating periods, calving dates, and calving areas for the Cook Inlet beluga whale are not well documented; however, calves are present during summer (Hobbs et al. 2005; Huntington 2000). Monitoring and mitigation measures will be implemented during construction of the PCT Project to minimize the number of takes by Level B disturbance caused by in-water pile installation, including use of shutdowns when beluga whales approach the proposed Level B harassment zone. There is a small chance that a few individual calves may be exposed to noise from pile-installation and removal; however, the overall impacts to the population are expected to be negligible.

7.2.1 Zone of Hearing Loss, Discomfort, or Injury

Very strong sounds can cause temporary or permanent reduction in hearing sensitivity. No studies have determined levels that cause PTS in beluga whales. Laboratory experiments investigating Temporary Threshold Shift (TTS) onset for beluga whales have been conducted. Finneran et al. (2000) exposed a trained captive beluga whale to a single pulse from an explosion simulator. No TTS threshold shifts were observed at the highest received SELs (179 dB re 1 μPa^2-s; approximately 199 dB rms); amplitudes at frequencies below 1 kHz were not produced accurately to represent predictions for the explosions. Finneran et al. (2002) repeated the study using seismic water guns with a single acoustic pulse. Masked hearing TTS was 7 and 6 dB at 0.4 and 30 kHz, respectively, after exposure to intense single pulses (186 dB SEL; 208 dB rms). Schlundt et al. (2000) demonstrated temporary shifts in masked hearing thresholds for beluga whales occurring generally between 192 and 201 dB rms (192 to 201 dB SEL) after exposure to intense, non-pulse, 1-second tones at 3, 10, and 20 kHz. TTS onset occurred at mean SEL of 195 dB rms (195 dB SEL). Popov et al. (2013) conducted studies of TTS in a captive male and a captive female beluga whale. The fatiguing noise had a 0.5-octave bandwidth, with center frequencies ranging from 11.2 to 90 kHz, a level of 165 dB re 1 μPa and exposure lasting 1 to 30 minutes. The highest TTS with the longest recovery duration was produced by noises of lower frequencies (11.2 and 22.5 kHz) and appeared at a test frequency of +0.5 octave. At higher noise frequencies (45 and 90 kHz), the TTS decreased. The TTS effect gradually increased with prolonged exposures ranging from 1 to 30 minutes. In a variety of exposure and recording conditions, TTS in the female subject was higher and longer than in the male subject, further illustrating that inter-individual difference must be taken into consideration when possible impacts to hearing are assessed. Popov et al. (2013) measured a TTS onset of 158 dB maximum accumulated sound exposure level (SEL_{cum}) from a female beluga whale.

Kastelein et al. (2013a) determined that the hearing threshold was lower when a harbor porpoise was exposed to multiple strike sounds than when it was exposed to only a single strike sound. Using a psychophysical technique, a harbor porpoise's hearing thresholds were obtained for series of five pile-driving sounds (inter-pulse interval 1.2 to 1.3 seconds) recorded at 100 and 800 meters from the pile-driving site, and played back in a pool. The 50 percent detection threshold SELs for the first sound of the series (no masking) were 72 (100 meters) and 74 (800 meters) dB re 1 μPa^2-s. Multiple sounds in succession (series) caused a 5-dB decrease in hearing threshold.

During in-air auditory threshold testing, Kastak and Schusterman (1996) inadvertently exposed a harbor seal to broadband construction noise for 6 days, averaging 6 to 7 hours of intermittent exposure per day. When the harbor seal was tested immediately upon cessation of the noise, a TTS of 8 dB at 100 Hz was evident. Following 1 week of recovery, the subject's hearing threshold was within 2 dB of its original level. Pure-tone sound detection thresholds were obtained in water for a harbor seal before and immediately following exposure to octave-band noise (Kastak et al. 1999). Test frequencies ranged from 100 Hz to 2 kHz, and octave-band exposure levels were approximately 60 to 75 dB source level. The subject was trained to dive into a noise field and remained stationed underwater during a noise-exposure period that lasted a total of 20–22 minutes. Following exposure, the harbor seal showed threshold shifts averaging 4.8 dB. The average threshold shift relative to baseline thresholds following noise exposure was 4.8 dB, and the average shift following the recovery period was 20.8 dB (Kastak et al. 1999).

Noise may affect physiology and developmental, stress, reproductive, or immune functions. Norman (2011) reviewed environmental and anthropogenic stressors for Cook Inlet beluga whales. Lyamin et al. (2011) determined that heart rate of a beluga whale increases in response to noise, depending on the frequency and intensity. Acceleration of heart rate in the beluga whale is the first component of the “acoustic startle response.” Romano et al. (2004) demonstrated that captive beluga whales exposed to high-level impulsive sounds (i.e., seismic airgun and/or single pure tones up to 201 dB rms) resembling sonar pings showed increased stress hormone levels of norepinephrine, epinephrine, and dopamine when TTS was reached. Thomas et al. (1990) exposed beluga whales to playbacks of an oil-drilling platform in operation (“Sedco 708,” 40 Hz–20 kHz; source level 153 dB). Ambient SPL at ambient conditions in the pool before playbacks was 106 dB and 134 to 137 dB during playbacks at the monitoring hydrophone across the pool. All cell and platelet counts and 21 different blood chemicals, including epinephrine and norepinephrine, were within normal limits throughout baseline and playback periods, and stress response hormone levels did not increase immediately after playbacks. The difference between the Romano et al. (2004) and Thomas et al. (1990) studies could be the differences in the type of sound (oil drilling versus simulated underwater explosion), intensity and duration of the sound, the individual’s response, and the surrounding circumstances of the individual’s environment (Romano et al. 2004). The construction sounds in the Thomas et al. (1990) study would be more similar to those of pile installation than those in the study investigating stress response to water guns and pure tones. Therefore, no more than short-term, low-hormone stress responses, if any, of beluga whales or other marine mammals will be expected as a result of exposure to pile installation.

Some species of odontocetes may have the ability to dampen hearing sensitivity in expectation of loud noise. Dampening has been observed in captive bottlenose dolphins (Nachtigall et al. 2016a), false killer whales (Nachtigall and Supin 2013), beluga whales (Nachtigall et al. 2015), and, to a lesser degree, harbor porpoises (Nachtigall et al. 2016b). When animals were given a series of warning pips in advance of a louder noise, hearing threshold shifted. For false killer whales, bottlenose dolphins, and beluga whales, the magnitudes, durations, and timing of both threshold shift and recovery in relation to the warning and loud sounds indicated a conditioned dampening response rather than noise-induced threshold shift (NITS; Nachtigall and Supin 2013; Nachtigall et al. 2015, 2016a). For harbor porpoises, data suggested that both a conditioned response and NITS contributed to the observed threshold shifts (Nachtigall et al. 2016b).

7.2.2 Zone of Masking

Pile-installation operations could result in minor masking through overlapping frequencies of the marine mammal signals or by increasing sound levels such that animals are unable to detect important signals over the increased noise. A passive acoustic study in the vicinity of the MTRP during its 2009 construction season measured noise to be less than 10 kHz, with one exception of impact pile installation, which extended to 20 kHz (Širović and Kendall 2009). Impact pile installation is less likely to mask beluga whale vocalizations than vibratory pile installation, because the frequency bandwidth from vibratory methods is within the range of whistles and noisy vocalizations (up to 10 kHz; Kendall 2010).

Beluga whale whistles have dominant frequencies in the 2 to 6 kHz range; other beluga whale call types include sounds at mean frequencies ranging upward from 1 kHz (Sjare and Smith 1986a, 1986b). The acoustic data from 2009 did not include any vocalizations other than echolocation clicks, indicating that beluga whales in the area may be focused on foraging as opposed to social behaviors (Saxon-Kendall et al. 2013). In response to loud noise, beluga whales may shift the frequency of their echolocation clicks to prevent masking by anthropogenic noise (Tyack 2000). Beluga whale echolocation has peak frequencies from 40 to 120 kHz and broadband source levels of up to 219 dB at 1 meter (Au et al. 1985). Killer whales produce whistles between 1.5 and 18 kHz, and pulsed calls between 500 Hz and 25 kHz (Ford and Fischer 1983 as cited in Richardson et al. 1995). Harbor porpoises produce acoustic signals in a very broad frequency range, <100 Hz to 160 kHz (Verboom and Kastelein 2004). The echolocation clicks produced by the aforementioned marine mammals are far above the frequency range of the sounds produced by vibratory pile driving and other construction sounds (e.g., dredging and gravel fill). Harbor seals produce social calls at 500 to 3,500 Hz and clicks from 8 to 150 kHz (reviewed in Richardson et al. 1995).

Increased noise levels could also result in minor masking of some marine mammal signals. Blackwell (2005) and URS (2007) reported that background noise at the POA (physical environment and maritime operations) contributed more to received levels than did pile installation at distances greater than 1,300 meters from the source. Therefore, beluga whales and other marine mammals in the POA area have likely become habituated to increased noise levels.

Implementation of the proposed mitigation measures will reduce impacts on marine mammals (Section 11), with any minor masking occurring close to the sound source, if it at all. The area of the PCT Project construction activities is a very small area of ensonification relative to the width and size of Knik Arm, further reducing any effects on marine mammals. Beluga whales are able to adjust vocalization amplitude and frequency in response to increased noise levels (Scheifele et al. 2005). However, the energetic costs of adjusting vocalizations in response to increased noise levels is poorly understood, and it is uncertain how this will affect individual animals. As a result of the intermittent nature of pile installation and removal and the relatively low use of the PCT Project area by beluga whales, the likelihood of in-water pile-installation and removal operations masking beluga whale social calls or echolocation clicks is low.

7.2.3 Zone of Responsiveness

Responses from marine mammals in the presence of pile-installation and removal activities might include a reduction of acoustic activity, a reduction in the number of individuals in the area, and avoidance of the area (e.g., Brandt et al. 2011; Dähne et al. 2013; Tougaard et al. 2012). Of these, temporary avoidance of the noise-impacted area is the most common response of marine mammals. Avoidance responses may be initially strong if the marine mammals move rapidly away from the source or weak if animal movement is deflected only slightly away from the source. Noise from pile installation/removal could potentially displace marine mammals from the immediate area of the activity. However, marine mammals will likely return after completion of pile-driving activities, as demonstrated by a variety of studies about temporary displacement of marine mammals by industrial activity (reviewed in Richardson et al. 1995).

Beluga whales in Cook Inlet have continued to utilize the habitat in the POA vicinity and Knik Arm despite it being heavily disturbed from maritime operations, maintenance dredging, and aircraft. Cook Inlet beluga whales did not abandon the area of the POA or Knik Arm during the 2016 TPP or the MTRP (Kendall 2010; Cornick and Seagars 2016). Cook Inlet beluga whales were continually observed in the MTRP area, even in the presence of pile installation (Section 7.2.4). However, sightings of beluga whales may have increased along the western shoreline of Knik Arm during the MTRP in 2008–2009, relative to pre-construction sightings from 2005 to 2007, indicating possible avoidance of the activity at the MTRP site (Kendall 2010). Sonobuoy data collected near the MTRP site in 2009 indicated fewer beluga echolocation clicks per hour during construction activities than when no construction was being performed; however, this difference was not statistically significant (Saxon-Kendall et al. 2013). Any masking event that could possibly rise to Level B harassment under the MMPA will occur concurrently within the zones of behavioral harassment already estimated for impact pile installation and removal, and have already been taken into account in the exposure analysis.

The presence of beluga whales in 2008–2011 during marine mammal monitoring for the MTRP followed a pattern similar to what has been observed prior to commencement of pile installation at the POA, including similar behaviors (diving and feeding) and peak abundance in late August and September, suggesting that pile-driving activities have not affected overall beluga whale behavior. Implementation of the mitigation measures during the MTRP reduced impacts on individual beluga whales to a short-term, temporary disturbance (i.e., Level B takes). Beluga whales have been observed during the same time period (peaking in September and October) in the POA area despite the presence of in-water construction and other maritime activities (Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick et al. 2011; Kendall 2010; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). There is no evidence to suggest that pile-installation operations at the POA affected beluga whale use of Knik Arm as a whole, as evidenced by the consistency of timing, location, and numbers of beluga whales (including calves; Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008, 2009; Cornick et al. 2011; Kendall 2010; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). These reports indicate that beluga whales are primarily transiting through the POA area while opportunistically foraging, and project construction, harbor dredging, and other maritime activities are not blocking this transit. Therefore, impacts on the Cook Inlet beluga whale population from the proposed PCT Project in-water construction activities are expected to be negligible.

To estimate the discomfort threshold of pile-installation sounds on a harbor porpoise, Kastelein et al. (2013a) exposed a captive individual to playbacks (46 strikes/minute) at five SPLs (6 dB steps: 130 to 154 dB re 1 μPa). At and above a received broadband SPL of 136 dB re 1 μPa (zero-peak SPL: 151 dB re 1 μPa; t90: 126 milliseconds; SEL of a single strike: 127 dB re 1 μPa^2-s) the porpoise's respiration rate increased in response to the pile-installation sounds. At higher levels, the individual also jumped out of the water more often (Kastelein et al. 2013b). The effects of pile-driving noise were studied by Tougaard et al. (2003) during the construction of the offshore wind farms at Horns Reef (North Sea) and Nysted (Baltic). At Horns Reef, the acoustic activity of harbor porpoises decreased shortly after each pile-driving event and went back to baseline conditions after 3 to 4 hours. However, harbor porpoises in Cook Inlet are currently exposed to a variety of industrial sounds and return to upper Cook Inlet each year, suggesting a level of habituation.

There are no studies that have focused on the effects of pile-driving noise on killer whales. However, since killer whales are rarely sighted near the POA, it is unlikely that killer whales will be exposed to pile-driving noise that masks acoustic communication.

A study by Kastelein et al. (2013c) showed that the hearing threshold for harbor seals exposed to playbacks of pile installation noise was lower when the animals were exposed to multiple strike sounds than it would be if they were exposed to a single strike sound. The harbor seal's unmasked hearing threshold level for pile installation sounds was found to be many orders of magnitude (ca. 130 dB) lower than the level measured at a distance of 800 meters from an offshore pile installation location. Kastelein et al. (2013c) noted that this suggests that pile-driving sounds are audible to harbor seals at distances on the order of hundreds of kilometers from pile-driving sites, depending on the actual propagation conditions and the masking of the sounds by ambient noise. Kastak et al. (1999) reported that pinniped behavior was often altered during experiments to assess TTS, reflected in hauling out, aggression directed at the apparatus and at the trainer, and refusal to station at the apparatus during noise exposure. Kastak et al. (1999) noted that these altered behaviors in the form of increased levels of aggression and/or avoidance of a location at which food had been received prior to noise exposure should be considered in the context of free-ranging seals that might respond similarly to uncomfortable noise exposures.

It is important to understand that there is variation among individual animals in behavioral reactions to sounds. For example, during in-water pile driving at Hood Canal, Washington, during fall 2011, harbor seals (particularly juveniles) appeared to be attracted to pile-driving activities, and often moved toward the construction area when pile driving was initiated (Ampela et al. 2014).

7.2.4 Habituation and Desensitization

Repeated or sustained disruption of important behaviors (such as feeding, resting, traveling, and socializing) is more likely to have a demonstrable impact than a single exposure (Southall et al. 2007). However, it is possible that marine mammals exposed to repetitious construction sounds will become habituated, desensitized, and tolerant after initial exposure to these sounds, as demonstrated by beluga whale tolerance of larger vessels in industrialized areas such as the St. Lawrence River and Beaufort Sea (reviewed by Richardson et al. 1995). Cook Inlet beluga whales are familiar with, and likely habituated to, the presence of large and small vessels. Beluga whales are frequently sighted in and around the POA, the Port MacKenzie Dock, and the small boat launch adjacent to the outlet of Ship Creek (Blackwell and Greene 2003; Funk et al. 2005; Ireland et al. 2005; NMFS 2008a). For example, Cook Inlet beluga whales did not appear to be bothered by the sounds from a passing cargo freight ship (Blackwell and Greene 2003).

Although the POA area is a highly industrialized area supporting a large amount of ship traffic, beluga whales are present almost year-round. Despite increased shipping traffic and upkeep operations (e.g., dredging) beluga whales continue to utilize waters within and surrounding the POA area, interacting with tugs and cargo freight ships (Markowitz and McGuire 2007; NMFS 2008a). During the POA monitoring studies, animals were consistently found in higher densities in the nearshore area (6 km^2) around the POA area throughout April to October each year where vessel presence was highest. Cook Inlet beluga whales were continually observed in the MTRP area, even in the presence of pile installation activity. In comparing pre- and post-pile-driving observations, Kendall (2010) reported a decrease in sighting duration of beluga whales; the increase in travel and the increased sightings near Port MacKenzie may indicate avoidance behavior by beluga whales in the area around the MTRP. It should be noted that Cornick et al. (2011) remarked that, during 2011 monitoring, beluga whales in the area of the MTRP appeared to have returned to similar habitat use, behavior, and group structure patterns that were in place prior to 2010, which may have been related to the reduced occurrence of pile driving and other in-water construction activities.

Carstensen et al. (2006) and Brandt et al. (2011) observed a decrease in harbor porpoises in the presence of pile-driving activity during the construction of offshore wind turbines near Denmark. Harbor porpoises returned to the construction area between pile-driving events; however, the return time occasionally took several days (Carstensen et al. 2006). Brandt et al. (2011) observed the reduction of harbor porpoise activity and density at the construction area over the entire period during which pile driving took place (5 months), also documenting increased use of areas 20 kilometers away from the construction site.

These studies indicate that beluga whales have become desensitized and habituated to the present level of human-caused disturbance. Therefore, it is anticipated that beluga whales will become habituated to the pile installation and removal noise. Cook Inlet beluga whales have demonstrated a tolerance to ship traffic around the POA. Animals will be exposed to greater than current background noise levels from pile installation and removal; however, background sound levels in Knik Arm are already high due to strong currents, eddies, recreational vessel traffic, U.S. Coast Guard patrols, dredging, and commercial and military shipping traffic entering and leaving the POA (Blackwell 2005; Blackwell and Greene 2003; KABATA 2011; URS 2007). Based upon the already elevated background noise around the POA area and a beluga whale's ability to compensate for masking, it can be reasonably expected that beluga whales will become habituated to pile installation as they have to vessel traffic. It is expected that frequency and intensity of behavioral reactions, if present, will decrease when habituation occurs.

7.3 Assessment of Impacts on Cook Inlet Beluga Whale Stock

Anthropogenic noise is ranked as one of three threats of "high relative concern" to the recovery of Cook Inlet beluga whales (NMFS 2016). As discussed above, anthropogenic noise can affect beluga whale communication, behavior, and echolocation, and alter the distribution or abundance of prey resources. Chronic exposure to anthropogenic noise may decrease survival and reproduction, with population-level consequences. However, the magnitude of this impact on Cook Inlet beluga whales and the potential for increasing exposure to result in population-level effects is currently unknown. In order to address whether noise is limiting the recovery of the Cook Inlet beluga whale population, Tollit et al. (2016) developed an interim population consequences of disturbance (iPCoD) model. This model builds on the concept that species perceive human disturbance as a threat, which results in behavioral and physiological responses that adversely affect individual health (Tollit et al. 2016). Currently, there are limited empirical data to explain how and to what extent anthropogenic noise in Cook Inlet results in changes to beluga whale behavior, reproduction, or individual survival. To fill this data gap, Tollit et al. (2016) convened a workshop in April 2016 in which expert elicitation was gathered and incorporated in the iPCoD model. The model was then used to assess population-level impacts from a hypothetical pile-installation project with different levels of beluga whale exposure over multiple years. Under all scenarios, the effect of anthropogenic noise disturbance on vital rates was so small that it was considered unlikely to result in population-level effects (Tollit et al. 2016).

7.4 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to SPLs during pile installation and removal associated with the PCT Project that may exceed Level B harassment. In addition, small numbers of harbor seals, Steller sea lions, and harbor porpoises may be exposed to Level A harassment. Marine mammals that are "taken" (i.e., harassed) may change their normal behavior patterns (e.g., swimming speed or foraging habits) or be temporarily displaced from the area of pile installation or removal. Any "takes" will likely have only a minor effect on individuals due to the short-term, temporary nature of the noise and the project. No measurable effect on Cook Inlet beluga whale, harbor seal, Steller sea lion, killer whale, harbor porpoise, or humpback whale populations is anticipated. Implementation of mitigation measures proposed in Section 11 is likely to avoid most potential adverse underwater impacts to marine mammals from pile installation or removal. Nevertheless, some level of impact is unavoidable. The expected level of unavoidable impact (defined as an acoustic or harassment "take") is described in Section 6.

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8 Description of Potential Impacts to Subsistence Uses

While no significant subsistence activity currently occurs within or near the POA, Alaska Natives have traditionally harvested subsistence resources, including marine mammals, in upper Cook Inlet for millennia. Beluga whales are more than a food source; they are important to the cultural and spiritual practices of Cook Inlet Native communities (NMFS 2008b). Dena'ina Athabascans, currently living in the communities of Eklutna, Knik, Tyonek, and elsewhere, occupied settlements in Cook Inlet for the last 1,500 years and have been the primary traditional users of this area into the present.

NMFS estimated 65 whales per year (range 21–123) were killed between 1994 and 1998, including those successfully harvested and those struck and lost. NMFS concluded that this number was high enough to account for the estimated 14 percent annual decline in population during this time (Hobbs et al. 2008); however, given the difficulty of estimating the number of whales struck and lost during the hunts, actual mortality may have been higher. During this same period, population abundance surveys indicated a population decline of 47 percent, although the reason for this decline should not be associated solely with subsistence hunting and likely began well before 1994 (Rugh et al. 2000).

In 1999, a moratorium was enacted (Public Law 106-31) prohibiting the subsistence harvest of Cook Inlet beluga whales except through a cooperative agreement between NMFS and the affected Alaska Native organizations. NMFS began working cooperatively with the Cook Inlet Marine Mammal Council (CIMMC), a group of tribes that traditionally hunted Cook Inlet beluga whales, to establish sustainable harvests. CIMMC voluntarily curtailed its harvests in 1999. In 2000, NMFS designated the Cook Inlet stock of beluga whales as depleted under the MMPA (65 FR 34590). NMFS and CIMMC signed *Co-Management of the Cook Inlet Stock of Beluga Whales* agreements in 2000, 2001, 2002, 2003, 2005, and 2006. Beluga whale harvests between 1999 and 2006 resulted in the strike and harvest of five whales, including one whale each in 2001, 2002, and 2003, and two whales in 2005 (NMFS 2008b). No hunt occurred in 2004 due to higher than normal mortality of beluga whales in 2003, and the Native Village of Tyonek agreed to not hunt in 2007. Since 2008, NMFS has examined how many beluga whales could be harvested during 5-year intervals based on estimates of population size and growth rate, and determined that no harvests would occur between 2008 and 2012 or between 2013 and 2017 (see NMFS 2008b for equations). The CIMMC was disbanded by unanimous vote of the CIMMC member Tribes' representatives in June 2012, and a replacement group of Tribal members has not been formed to date. There has been no subsistence harvest of beluga whales since 2005 (NMFS 2016).

Harvests of harbor seals for traditional and subsistence uses by Native peoples are low in upper Cook Inlet. ADF&G (2018) has collected harvest data for harbor seals in Tyonek for the following years: 1996 (two seals harvested), 1997 (two seals harvested), 1998 (no seals harvested), 2000 (no seals harvested), 2001 (no seals harvested), 2002 (three seals harvested), 2003 (five seals harvested), 2004 (no seals harvested), 2005 (no seals harvested), 2006 (four seals harvested), 2007 (no seals harvested), 2008 (nine seals harvested), and 2013 (six seals harvested). ADF&G conducted more comprehensive harvest studies in 1983, when marine mammal harvests included no seals and one beluga whale (Fall et al. 1983), and in 2005, when marine mammal harvests included two beluga whales (Stanek et al. 2007).

Residents of the Native Village of Tyonek are the primary subsistence users in the upper Cook Inlet area. As project activities will take place within the immediate vicinity of the POA, no activities will occur in or near Tyonek's identified traditional subsistence hunting areas. As the harvest of marine mammals in upper Cook Inlet is historically a smaller portion of the total subsistence harvest, and the number of marine mammals using upper Cook Inlet is proportionately small, the number of marine mammals harvested in upper Cook Inlet is expected to remain low. As the proposed project will likely result in temporary disturbances to small numbers of marine mammals during construction, the project will not impact the availability of these other marine mammal species for subsistence uses.

9 Description of Potential Impacts to Marine Mammal Habitat

9.1 Effects of Project Activities on Marine Mammal Habitat

Habitat is the locality or environment that is essential for an animal's survival, where it feeds, rests, travels, socializes, breeds, and raises its young. For cetaceans, these are in-water areas, whereas for pinnipeds, habitat also includes haulout sites or rookeries. In addition to physical locations, habitat also includes the prey upon which a marine mammal feeds.

The Cook Inlet beluga whale is the only marine mammal species in the project area with critical habitat designated in Cook Inlet. The area around the POA (Figure 4-1) was excluded from the critical habitat designation for national security reasons (76 FR 20180). However, there is potential for effects upon critical habitat beyond the exclusion zone; these are discussed in Section 4.5.2. Section 7 consultation under the ESA requires an analysis of potential effects on critical habitat; therefore, the Biological Assessment being prepared for the PCT Project will provide detailed information on potential effects to designated critical habitat for the Cook Inlet beluga whale.

The PCT Project will be located in an area that has been highly modified by industrial activity, including annual dredging. The project area experiences high levels of vessel traffic and relatively high underwater and in-air noise levels. The project area is not considered to be high-quality habitat for marine mammals or marine mammal prey, such as fish. The most likely impact to marine mammal habitat would be the displacement of marine mammal prey at and near the POA and minor impacts to the immediate substrate during installation and removal of piles during the PCT Project. Long-term effects of any prey displacements are not expected to affect the overall fitness of individual marine mammals or adversely affect marine mammal populations; effects will be minor and will terminate after cessation of PCT Project construction.

Although excluded from the critical habitat designation for Cook Inlet beluga whales under the ESA, the POA provides habitat for beluga whales and their prey. Direct impacts such as substrate modification from pile installation or indirect impacts to prey species could occur in this area. Additionally, underwater noise from pile installation and removal will be perceptible in designated critical habitat beyond the critical habitat exclusion zone.

Beluga whales use shallow, nearshore submarine channels to concentrate prey and, occasionally, to seek refuge from killer whales (NMFS 2016). The significance of these channels to successful foraging is an important factor in the designation of shallow intertidal and subtidal waters of Cook Inlet as the first PCE of the critical habitat. Pile installation may alter the substrate and bathymetry in the immediate area around the pile; however, all pile installation and removal will occur within the exclusion zone. Although the exclusion zone contains beluga whale habitat, the areas that would be affected by pile installation and removal are already highly modified by structures and POA activities, and are poor-quality marine mammal habitat.

Level A harassment zones for impact installation and vibratory installation and removal will be entirely within the POA's critical habitat exclusion zone, for all pile sizes and with or without use of a bubble curtain (Figure 6-9 through Figure 6-12). For many of the piles (139), Level B zones will be entirely within the critical habitat exclusion zone (Figure 6-9 through Figure 6-13):

- Impact hammer installation of 48-inch piles with a bubble curtain (71 piles) and
- Vibratory hammer installation and removal of plumb 24-inch piles with a bubble curtain (68 piles).

Level B zones will extend beyond the critical habitat exclusion zone for the following pile configurations (up to 145 piles; Figure 9-1):

- Impact hammer installation of 144-inch piles with a bubble curtain (9 piles);
- Vibratory hammer installation and removal of 36-inch piles with a bubble curtain (106 piles);
- Vibratory hammer installation and removal of 24-inch battered piles without a bubble curtain (22 piles);
- Potential vibratory hammer installation of 48-inch piles with a bubble curtain (up to 7 piles) due to encountering obstructions, or constructability or safety issues; and
- Potential vibratory hammer installation of 144-inch piles with a bubble curtain (1 pile) due to encountering obstructions, or constructability or safety issues.

However, even the larger vibratory Level B zone sizes for 24-, 36-, and 48-inch piles do not extend to the western shore of Knik Arm (Figure 6-13). During all pile installation and removal for the most likely construction scenario, there will be waters along the western shore of Knik Arm that are not ensonified, permitting beluga whales and other marine mammals to transit through the project area—and between areas of critical habitat—without being exposed to noise levels that exceed the Level B harassment criteria. This condition, of unrestricted passage within or between critical habitat areas, is a Primary Constituent Element (PCE) of Cook Inlet beluga whale critical habitat as designated (76 FR 20180).

Only when impact pile installation is not feasible for a 144-inch pile, such as when maneuvering a pile around a rock or other obstacle, will vibratory installation be used, resulting in a Level B zone that extends across Knik Arm. It is estimated that vibratory hammer application will be used on a single 144-inch pile on a single day, with negligible impacts on marine mammals, including beluga whales and their habitat.

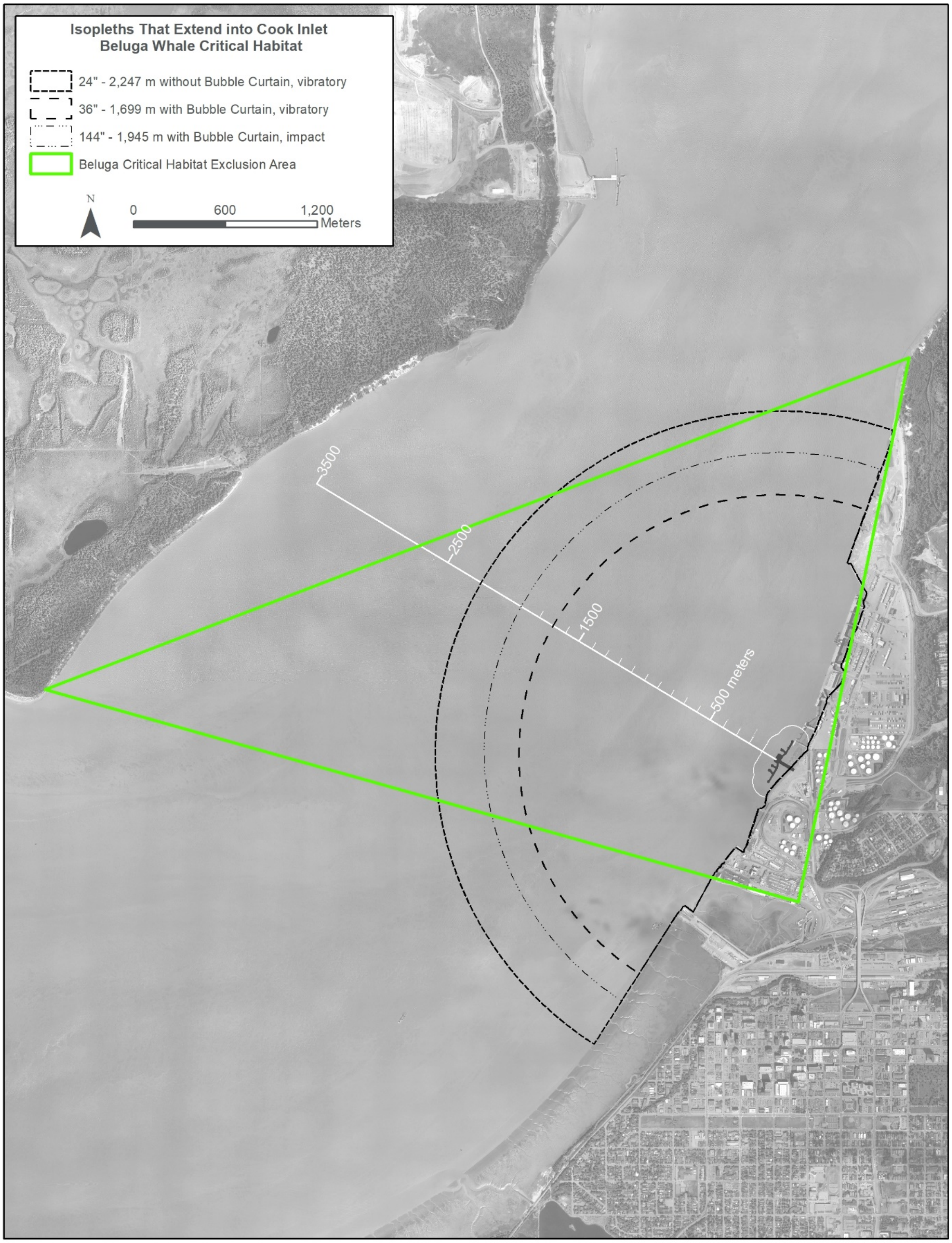

Figure 9-1. Largest Isopleths for Pile Installation during the Most Likely Construction Scenario during PCT Construction

9.2 Effects of Project Activities on Marine Mammal Prey

As noted in Section 4, Cook Inlet beluga whales, harbor seals, harbor porpoises, Steller sea lions, and killer whales, and humpback whales are found in the area. The following section presents information on prey preferences for marine mammal species in the area, and possible effects of the PCT Project construction on those prey items.

The diets of Cook Inlet beluga whales in Knik Arm can be generalized based on a comparison of fishes found in stomach analyses of beluga whales and fish species observed in Knik Arm (Houghton et al. 2005). Cook Inlet beluga whales appear to feed on a wide variety of prey species, focusing on species that are seasonally abundant. Common prey species in Knik Arm include salmon, eulachon, and Pacific cod (Houghton et al. 2005; Quakenbush et al. 2015; Rodrigues et al. 2006, 2007). There are anecdotal reports of Cook Inlet beluga whales feeding on Pacific herring, Pacific tomcod, lingcod (*Ophiodon elongatus*), steelhead trout (*Oncorhynchus mykiss)*, flatfishes, and humpback whitefish (*Coregonus oidschian)* (Huntington 2000; NMFS 2008a).

Harbor seals are opportunistic feeders whose diet varies with season and location. The preferred diet of the harbor seal in the Gulf of Alaska consists of pollock, octopus, Pacific capelin (*Mallotus villosus*), eulachon, and Pacific herring (Sease 1992). Other prey species include cod, flat fishes, shrimp, salmon, and squid (Hoover 1988). Harbor seals in lower Cook Inlet move in response to local steelhead trout and salmon runs (Montgomery et al. 2007) and have been documented feeding on salmon in proximity to beluga whales in upper Cook Inlet (Easley-Appleyard et al. 2011). Harbor porpoises forage on prey similar to that of Cook Inlet beluga whales (Shelden et al. 2014): primarily Pacific herring, other schooling fish, and cephalopods (Leatherwood et al. 1982). Killer whales feed on either fish or other marine mammals, depending on ecotype (resident versus transient, respectively). Occasional occurrences of killer whales in Knik Arm are typically of the transient ecotype (Shelden et al. 2003); transients feed on beluga whales and other marine mammals, such as harbor seals and harbor porpoises.

Fish species in Knik Arm that are prey for marine mammals could be affected by noise from in-water pile installation. Although data on fish populations in upper Cook Inlet are limited, studies indicate that a wide variety of fish species, including five species of Pacific salmon, saffron cod, and forage fish, including eulachon and longfin smelt, are present in the vicinity of the POA. Marine waters surrounding the POA provide habitat for migrating, rearing, and foraging (Houghton et al. 2005; Moulton 1997). In general, fish perceive underwater sounds in the frequency range of 50 to 2,000 Hz, with peak sensitivities below 800 Hz (Popper and Hastings 2009).

Especially strong or intermittent sounds may elicit changes in fish behavior and local distribution, and could potentially harm fish. High underwater SPLs (such as those occurring during impact hammer pile installation) are documented to alter behavior, cause hearing loss, and injure or kill individual fish by causing serious internal injury (Hastings and Popper 2005). Results of laboratory studies of juvenile Chinook salmon suggested that mild injuries resulting from pile-driving exposure are unlikely to affect the survival of the exposed animals, at least in a laboratory environment (Casper et al. 2012). However, as noted by Popper et al. (2014), even those recoverable injuries could reduce fitness and lead indirectly to mortality in free-ranging fish. More difficult to assess is the disturbance of the natural behavior of fish or the masking of communication and orientation signals due to exposure to lower noise levels (Hastings and Popper 2005). No data are available on TTS or masking for fish exposed to pile driving, nor are there data on behavioral responses (Popper et al. 2014). Masking may occur for the duration that fish are exposed to pile driving, and, as noted by Popper et al. (2014), it is not possible to say how long behavioral effects, if any, would continue following impact hammer operation.

Regulations for impact hammer pile installation currently utilize a dual interim criteria approach for onset of physiological effects to fish (Fisheries Hydroacoustic Working Group 2008; Stadler and

Woodbury 2009; Woodbury and Stadler 2008). The acoustic criterion identifies peak SPL and accumulated sound SEL noise thresholds (re: 1 μPa) for injury to fish exposed to underwater noise from impact hammer pile installation as follows:

- Peak SPL is 206 dB (single strike) for any fish size;
- Accumulated SEL is 187 dB for fish weighing 2 grams or more; and
- Accumulated SEL is 183 dB for fish weighing less than 2 grams.

These criteria assume that fish may be injured when exposed to the peak SPL (206 dB) for a single strike and, depending on the size of the fish, an accumulated SEL of 183 dB or 187 dB. Injury to fish exposed to these noise levels can range from a brief acoustic annoyance to instantaneous lethal injury (Hastings and Popper 2005). NMFS currently uses a threshold of 150 dB rms re 1 μPa for behavioral disturbance to fish during impact pile driving. Impacts on fish have not been observed in association with vibratory hammers (WSDOT 2018). Cumulative SEL fish injury criteria do not exist for vibratory pile installation.

During the PAMP 2016 TPP, the POA collected site-specific underwater acoustic data while 48-inch-diameter steel pipe piles were installed using impact hammers with and without noise attenuation systems. A passive resonator system was deployed during installation of four piles, and a confined bubble curtain was deployed during the installation of four other piles; two piles were installed without any noise attenuation systems during the spring 2016 TPP. Based largely on these data, Illingworth & Rodkin (2017) identified sound levels, frequency characteristics, and TL coefficients appropriate to predict distances to noise thresholds for impact hammer pile installation during the PCT Project. Estimated distances to noise thresholds for fish during impact hammer driving using the NMFS calculator are summarized in the *Anchorage Port Modernization Program Essential Fish Habitat Technical Memorandum – APMP Petroleum and Cement Terminal Project* (POA 2017a).

Based on these estimates, installation of 48- and 144-inch inch-diameter piles with an impact hammer is expected to produce underwater sound pressure waves that may displace, harm, or kill primary prey species in Knik Arm. Adults and juveniles of five Pacific salmon species, eulachon, longfin smelt, saffron cod, and other species use habitat throughout Knik Arm during the timeframe in which impact pile installation is anticipated to occur. Fish response is difficult to predict, and the extent of injury or harm to fish is difficult to quantify. The response of fish exposed to interim injury thresholds could range from no effect or a brief acoustic annoyance to instantaneous lethal injury (Hastings and Popper 2005). No behavioral abnormalities, injuries, or mortalities were observed in juvenile salmon exposed to 177 dB and 195 dB peak and accumulated SELs ranging from 179.2 to 190.6 dB during sheet-pile driving at the POA (Hart Crowser et al. 2009). A study to evaluate effects of impact pile-driving sound on juvenile coho salmon exposed them to peak SPLs of 208 dB and cumulative SELs of 207 dB during a 4-hour period; no juvenile salmon died, no gross external or internal injuries were observed, and behavioral responses were subtle (Ruggerone et al. 2008).

In general, the nearer the animal is to the source, the greater the likelihood of high energy and a resultant effect (such as mild, moderate, or mortal injury). Small fish such as juvenile salmon may be the most susceptible to injury or mortality from noise associated the peak SPL for a single strike because of their small body mass (Yelverton et al. 1975), entrainment within swift currents, and distribution throughout Knik Arm from May to August (Houghton et al. 2005). However, the strong currents within Knik Arm would limit the potential for a juvenile salmon to occupy habitat in proximity to impact hammer operation for extended periods.

During the MTRP, the effects of impact and vibratory installation of 30-inch-diameter steel sheet piles at the POA on 133 caged juvenile coho salmon in Knik Arm were studied (Hart Crowser et al. 2009; Houghton et al. 2010). Maximum peak SPLs observed ranged from 177 to 195 dB re 1 μPa, and accumulated SELs ranged from 174.8 to 190.6 dB re 1 μPa. Acute or delayed mortalities, or behavioral abnormalities were not observed in any of the coho salmon. Furthermore, results indicated that the pile driving had no adverse effect on feeding ability or the ability of the fish to respond normally to threatening stimuli (Hart Crowser et al. 2009; Houghton et al. 2010). In light of studies (Hart Crowser et al. 2009; Houghton et al. 2010) of fish in cages exposed to pile driving that showed no physical trauma to fish exposed to levels significantly above a cumulative SEL of 187 dB (Popper et al. 2013), Popper et al. (2014) re-examined the SEL_{cum} threshold and published interim sound exposure guidelines for fish from pile installation (Table 9-1).

Table 9-1. Interim Sound Exposure Guidelines for Exposure of Fish to Pile Installation Noise

Type of Animal	Mortality and Potential Mortal Injury	Recoverable Injury	TTS	Masking	Behavior
Fish: no swim bladder (particle motion detection)[a]	Mortality and potential mortal injury	>216 dB SEL_{cum} or >213 dB peak	>>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)[b]	210 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)[c]	207 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	186 dB SEL_{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Eggs and larvae	>210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
Fish: no swim bladder (particle motion detection)[a]	Mortality and potential mortal injury	>216 dB SEL_{cum} or >213 dB peak	>>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low

[a] Eulachon, flounder.

[b] Salmon.

[c] Pacific cod.

Source: Popper et al. 2014.

Notes: TTS = temporary threshold shift; dB = decibels; SEL_{cum} = cumulative sound exposure level. Peak and rms sound pressure levels are reported in dB re 1 µPa; SEL is reported in dB re 1 $\mu Pa^2 \cdot s$. 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 defined in relative terms as near (N), intermediate (I), and far (F) from the pile-driving source. While it would not be appropriate to ascribe particular distances to effects because of the many variables in making such decisions, “near” might be considered to be in the tens of meters from the source, “intermediate” in the hundreds of meters, and “far” in the thousands of meters. The *relative* risk of an effect is then rated as being “high,” “moderate,” or “low” with respect to source distance and animal type. No assumptions are made about source or received levels because there are insufficient data to quantify what these distances might be. However, in general, the nearer the animal is to the source, the higher the likelihood of high energy and a resultant effect.

While some fish within the distance to fish injury criteria may be harmed, impacts on primary prey species would otherwise be short-term and local. The PCT Project is not anticipated to substantially impede migration of adult or juvenile salmon or adversely affect the health and survival of the affected species at the population level. Affected fish would represent only a portion of food available to marine mammals in the area. Once impact hammering has ceased and construction of the PCT is complete, habitat quality would be expected to return to pre-PCT Project conditions. The only exception would be habitat lost due to the presence of piles; however, this amount of habitat is minimal compared to the available habitat in adjacent Knik Arm waters. Fish would be expected to move into and use adjacent available areas. Potential effects on fish are discussed in more detail in the *Anchorage Port Modernization Program Essential Fish Habitat Technical Memorandum – APMP Petroleum and Cement Terminal Project* (POA 2017a).

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10 Description of Potential Impacts from Loss or Modification of Habitat to Marine Mammals

Descriptions of the potential impacts on habitat from construction of the PCT are discussed in Section 9. The effects from construction of the PCT on marine mammal habitat are expected to be temporary and minor (Section 9.1). An extremely small amount of low-quality marine habitat will be replaced by steel pilings, such that the permanent impacts to marine habitat are discountable. The greatest impact on marine mammals associated with the PCT Project will be a temporary loss of habitat because of elevated noise levels. Displacement of marine mammals by noise will not be permanent, and there will be no long-term effects to their habitat. Although the PCT Project will occur over multiple months (Section 2.1), pile installation and removal would occur only for a relatively small portion of each day, allowing ample recovery period should displacement or modification of behavior occur. The PCT Project is not expected to result in any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, since installation and removal of piles will be temporary and intermittent.

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11 Mitigation Measures

11.1 Pre-Construction

The POA is committed to minimizing impacts of its activities, including PCT construction, on beluga whales and other marine mammals. Therefore, the following measures have already been committed to or carried out by the POA as part of the PCT design and pre-construction processes, and are designed to avoid and minimize potential for disturbance or injury to marine mammals.

PCT Design Process

- Features removed from the preliminary design that reduce the amount and duration of pile installation:
  - Emergency access trestle (15, 48-inch piles)
  - 5, 48-inch main trestle piles
  - 5, 48-inch platform piles
  - Two dolphins (each having an 8-pile, 48-inch diameter battered pile group)
  - 20, 36-inch fender piles

- Modifications made to the preliminary design that reduce the amount and duration of pile installation:
  - Mooring and breasting dolphin design now incorporates a single 144-inch diameter monopile per pile (formerly an 8-pile, 48” diameter battered pile group per pile)
  - Permanent pile tip depths are now generally 30 feet shallower than preliminary design

PCT Pre-Construction Process

- Restricted use of a vibratory hammer to be used only for temporary pile installation and removal (due to larger harassment zones), except for limited use (estimated at 10%) of vibratory hammer application for permanent piles if obstructions, safety, or constructability issues are encountered
- Use of a bubble curtain on all temporary and permanent plumb piles

11.2 Construction

The POA is actively pursuing a USACE Section 10/404 permit for the PCT Project. Mitigation requirements under that permit have not yet been fully determined, but will require coordination among the POA, USACE, and NMFS. Mitigation requirements have also not been fully determined by NMFS. The following mitigation measures have been developed by the POA and are designed to avoid and minimize potential for injury and disturbance to marine mammals, particularly beluga whales, during construction of the PCT:

1. **Notification of Commencement of PCT Project Construction, Beluga Whale Sightings:** The POA will formally notify the NMFS Alaska Region office and the Office of Protected Resources prior to the commencement of pile installation and removal.
2. **Pile Installation and Removal**: The POA is committed to installing 48- and 144-inch piles using impact hammer pile installation methods to the extent feasible due to the smaller harassment zones. The temporary 24- and 36-inch piles will be installed and removed using vibratory hammer methods. Impact hammer installation methods result in smaller Level B harassment

zones than vibratory hammer installation methods for similar pile sizes and types. The POA's commitment to use impact hammer installation methods on 48- and 144-inch piles greatly reduces the area of harassment (Level B), or zones of ensonification, compared to use of vibratory methods on similar pile sizes. This, in turn, reduces the overall area of elevated underwater noise exceeding harassment thresholds, and therefore reduces acoustic impacts on marine mammals. If impact hammer installation methods for 48- and 144-inch piles encounter obstructions, safety or constructability issues (estimated at 10% of these piles), it is anticipated that a vibratory hammer may be required for pile extraction or adjustment.

3. **Pile Installation at Low Tide:** Access trestle piles may be installed at low tide when the area is dewatered (in the dry) to reduce potential impacts on marine mammals. When a pile is installed or removed in the dry or in very shallow water, it will be assumed that no exposure occurs to noise that is defined as Level B harassment, and no take occurs of marine mammals. When the water is too shallow for deployment of a bubble curtain, the harassment zones for unattenuated impact pile installation will be monitored (Table 6-16 and Table 6-17; also see Section 1.3.5).
4. **Marine Mammal Monitoring**: Marine mammal monitoring will be conducted at the POA at all times when in-water pile installation or removal is taking place to avoid and minimize potential harassment exposures to marine mammals. Monitoring will be conducted by qualified Marine Mammal Observers (MMOs). General monitoring plan criteria are discussed in Section 13 and additional information is found in the marine mammal monitoring and mitigation plan in Appendix A.
5. **Hydroacoustic Monitoring**: In coordination with NMFS, a hydroacoustic monitoring study will be developed and implemented as part of PCT Project construction. A sound source verification study was conducted previously at the POA for the PAMP TPP in 2016. The goal of the hydroacoustic monitoring will primarily be to confirm the effectiveness of the bubble curtain system for future PAMP Phase 2 construction projects and incidental take authorization requests. Hydroacoustic data collection and analysis methods for the PCT Project will follow NMFS' guidance on hydroacoustic monitoring, including use of equipment, such as moorings, recording systems, hydrophones, and other hardware and software. General monitoring plan criteria are discussed in Section 13 and Appendix B, which will be further developed and coordinated with NMFS prior to PCT construction.
6. **Pre-activity Monitoring and Soft Starts:** MMOs will begin observing for marine mammals within the Level A and Level B harassment zones for at least 30 minutes before "soft start" or in-water pile installation or removal begins.
    - A ''soft start'' technique will be used at the beginning of impact pile installation each day to allow any marine mammal that may be in the immediate area to leave before pile driving reaches full energy. Soft starts will not be used for vibratory pile installation and removal. When the impact hammer is used, operators will provide an initial set of three strikes from the impact hammer at reduced energy, followed by a 30-second waiting period, then two subsequent three-strike sets.
    - If a marine mammal for which take is **not authorized** is sighted within the Level A or Level B harassment zones, a soft start will not commence until the MMO has determined, through sighting or by waiting 15 minutes without resighting, that the animal(s) has moved outside of the Level A and Level B harassment zones.
    - If a marine mammal for which Level B take is **authorized** is present within the Level A harassment zone, the soft start will be delayed until the animal(s) leaves the Level A harassment zone. Activity will begin only after the MMO has determined, through sighting, that the animal(s) has moved outside the Level A harassment zone.

- If a marine mammal for which Level B take is **authorized** is sighted within the Level B harassment zone after the 30-minute monitoring period but prior to soft start, the Contractor will either (1) begin soft start with documentation of take or (2) delay the soft start to avoid take of marine mammals. A soft start may occur whether a marine mammal enters the Level B zone from the Level A zone, or from outside the Project area.
- If a marine mammal for which Level A take is **authorized** is sighted within the Level A harassment zone, a soft start will not commence until the MMO has determined, through sighting or by waiting 15 minutes without resighting, that the animal(s) has moved outside of the Level A harassment zone.
- If the Level A and Level B zones have been monitored continuously during impact installation of the day's first pile, and the MMOs have confirmed that no marine mammals are observed within the Level A and Level B zones, impact installation of the successive pile will begin without a soft start.

7. **100-meter Shutdown Zone:** Based on the sound levels predicted for pile installation and removal (Section 6), the POA is proposing a 100-meter shutdown zone for all marine mammals during pile installation and removal. The 100-meter shutdown zone will avoid exposure of marine mammals to sound levels within the 100-meter zone. Although every effort will be made to shut down before marine mammals enter the 100-meter zone, if the Level A isopleth for a species is smaller than 100 meters, Level A take of that species will not occur unless individuals move across their respective Level A isopleths as defined in Table 6-16 and Table 6-17.
8. **Shutdown Procedures:** If a marine mammal is traveling along a trajectory that could take it into the Level B harassment zone, the lead MMO will notify the Contractor Point of Contact, who will decide to either (1) immediately shut down all in-water pile installation or removal before the marine mammal enters the Level B harassment zone, thereby avoiding a take, or (2) document the marine mammal as a take upon its entry into the Level B harassment zone. For safety or operational reasons, the immediate shutdown of in-water pile installation or removal may not be possible. The MMOs will document the reason behind each shutdown or non-shutdown decision. If the Contractor POC decides to continue pile installation or removal while a marine mammal is within the Level B harassment zone, that pile segment will be completed without cessation, unless the animal approaches and is likely to enter the Level A harassment zone. At that point, the Contractor POC will immediately shut down all in-water pile installation and removal before the marine mammal enters the Level A harassment zone, thereby avoiding a Level A take. For all marine mammal species for which take is not authorized, pile installation or removal will be shut down to avoid all take.
9. **Shutdown for Weather:** Pile installation and removal will take place only when the Level A harassment zones can be adequately monitored.
10. **Other In-Water Activities:** To avoid the potential for collision with a marine mammal during in-water work involving use of vessels (e.g., barges, tugboats, work boats, and skiffs), if a marine mammal approaches within 50 meters, vessels shall reduce speed to the minimum level required to maintain steerage and safe working conditions.
11. **Take Management:** If take levels approach authorized take levels during construction, the POA will re-engage with NMFS to determine an appropriate strategy for managing take over the remaining construction period. Construction means and methods will likely be adjusted as the project moves into the construction phase, and construction events may require some modifications to the parameters identified in this IHA application; however, all monitoring and take accumulations will be monitored within the tolerances of the overall take authorization,

and the applicant (Port of Alaska) will consult with NMFS for any significant deviations from the construction means and methods identified this IHA application. The assumed use of a vibratory hammer on 10 percent of 48- and 144-inch permanent piles due to encountering obstructions, safety or constructability conditions, or difficulty with plumbing a particular pile is only an estimate; additional vibratory hammer applications may be required for additional piles but will be managed within the tolerances of the overall take authorizations.

12. **Bubble Curtain**: The POA proposes to install a bubble curtain system around plumb piles, either individually or as a set, during installation and removal, as feasible, to reduce underwater sound pressure levels. The use of a bubble curtain during pile installation and removal will reduce the sizes of the Level A and Level B harassment zones, ultimately reducing impacts from noise on marine mammals. Tidal currents were measured at the PCT site for an extended period of time during design development and determined to below 3 knots maximum flow, primarily due to the PCT location and close proximity to the shoreline (note that current flows are much higher further offshore in Knik Arm), providing the opportunity to be within the tolerances for either an open flow or confined bubble curtain system. The bubble curtain system will be further developed during the pre-construction phase of the PCT Project once a Contractor is selected. To be compliant with the IHA, the bubble curtain must function properly when deployed. Performance specifications for the bubble curtain for the PCT Project will include adherence to the following general specifications to the maximum extent practicable:

    - A bubble curtain is composed of an air compressor(s), supply lines to deliver the air, distribution manifolds or headers, perforated aeration pipes, and a frame. The frame facilitates transport and placement of the system, keeps the aeration pipes stable, and provides ballast to counteract the buoyancy of the aeration pipes in operation.
    - The aeration pipe system shall consist of multiple layers of perforated pipe rings, stacked vertically in accordance with the following:

Water Depth (m)	No. of Layers
0 to less than 5	2
5 to less than 10	4
10 to less than 15	7
15 to less than 20	10
20 to less than 25	13

Note: m = meters.

    - The pipes in all layers shall be arranged in a geometric pattern which shall allow for the pile being installed or removed to be completely enclosed by bubbles for the full depth of the water column, and with a radial dimension such that the rings are 1 to 2 feet (0.30 to 0.61 meters) from the outside surface of the pile.
    - The lowest layer of perforated aeration pipe shall be designed to ensure contact with the substrate without burial and shall accommodate sloped conditions.
    - The design of the system must ensure that the system extends from the sea floor to the water surface during maximum water-current conditions and accommodate tidal changes.

- Air holes shall be 1/16 inches (1.6 millimeters) in diameter and shall be spaced approximately 3/4 inches (20 millimeters) apart. Note that air hole size may need to be adjusted to accommodate the silt-laden waters of Knik Arm. Air holes with this size and spacing shall be placed in four adjacent rows along the pipe to provide uniform bubble flux.

- For an unconfined bubble curtain, the system shall provide a bubble flux of 105 cubic feet (3.0 cubic meters [m3]) per minute per linear meter of pipe in each layer (32.91 cubic feet [ft3] per minute per linear foot of pipe in each layer). The volume of air per layer (Vt) is the product of the bubble flux and the circumference of the ring:

  V_t = 3.0 m^3/minute/meter * circumference of the aeration ring in meters
  or
  V_t = 32.91 ft^3/minute/foot * circumference of the aeration ring in feet
- Meters shall be provided as follows:
  - Pressure meters shall be installed at all inlets to aeration pipelines and at points of lowest pressure in each branch of the aeration pipeline.
  - Flow meters shall be installed in the main line at each compressor and at each branch of the aeration pipelines at each inlet. In applications where the feed line from the compressor is continuous from the compressor to the aeration pipe inlet, the flow meter at the compressor can be eliminated.
  - Flow meters shall be installed according to the manufacture's recommendation based on either laminar flow or non-laminar flow, which ever applies.
- Gauges must be installed above the water line and shall be accessible to the POA's Resident Engineer (RE) or designee. A continuous electronic log of meters and gauges must be maintained when the system is operating. Readings must be logged every 1 minute and at other times, as determined by the POA's RE, when variation in the readings exceeds I0 percent. A graphical plot showing the variation of the meter readings with time must be maintained.
- Air pressure and air flow meters and gauges must be calibrated by an independent testing laboratory approved by the POA's RE prior to use in the attenuator system. Meters shall be accurate to within 2 percent.

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12 Measures to Reduce Impacts to Subsistence Users

The PCT Project construction will occur in or near a traditional subsistence hunting area and could affect the availability of marine mammals for subsistence uses. Therefore, the POA will communicate with representative Native subsistence users and Tribal members to develop a Plan of Cooperation or other relevant information, as desired, which identifies the measures that have been taken or will be taken to minimize any adverse effects of PCT Project construction on the availability of marine mammals for subsistence uses.

The POA will adhere to the following procedures during Tribal consultation regarding marine mammal subsistence use within the project area:

(1) Write letters to the Kenaitze, Tyonek, Knik, Eklutna, Ninilchik, Seldovia, Salamatoff, and Chickaloon tribes informing them of the project (i.e., timing, location, and features). Include a map of the project area; identify potential impacts to marine mammals and mitigation efforts, if needed, to avoid or minimize impacts; and inquire about possible marine mammal subsistence concerns they have.

(2) Follow up with a phone call to the environmental departments of the eight Tribal entities to ensure they received the letter, understand the project, and have a chance to ask questions. Inquire about any concerns they might have about potential impacts to subsistence hunting of marine mammals.

(3) Document all communication between the POA and Tribes.

(4) If any Tribes express concerns regarding project impacts to subsistence hunting of marine mammals, then propose a Plan of Cooperation between the POA and the concerned Tribe(s).

The project features and activities, in combination with a number of actions to be taken by the POA during project implementation, should avoid or mitigate any potential adverse effects on the availability of marine mammals for subsistence uses. Furthermore, although construction will occur within the traditional area for hunting marine mammals, the project area is not currently used for subsistence activities. In-water pile installation and removal will follow mitigation procedures to minimize effects on the behavior of marine mammals, and impacts will be temporary.

If desired, regional subsistence representatives may support project marine mammal biologists during the monitoring program by assisting with collection of marine mammal observations, and may request copies of marine mammal monitoring reports.

It is anticipated that the PCT Project location, small size of the affected area, mitigation measures, and input from Tribal entities will result in project construction having no effect on subsistence use of marine mammals.

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13 Monitoring and Reporting

The POA proposes to implement a marine mammal monitoring and mitigation strategy intended to avoid and minimize impacts to marine mammals. The monitoring plan includes two general components: acoustic measurements and visual observations.

13.1 Marine Mammal Observations

The POA will collect data on marine mammal sightings and any behavioral responses to in-water pile installation or removal for species observed during pile installation and removal associated with the PCT Project. Four MMOs will work concurrently to provide full coverage for marine mammal monitoring in rotating shifts during in-water pile installation and removal. All MMOs will be trained in marine mammal identification and behaviors.

Before the PCT Project commences, the best practicable vantage point will be determined for the observation platform(s) for monitoring during in-water pile installation and removal. Considerations will include:

- Elevation of the observation platform, to maximize field of view and distance
- Ability to see Level A and Level B harassment zones, as well as the 100-meter shutdown zone
- Ability to see the shoreline, along which beluga whales commonly travel
- Safety of the MMOs, construction crews, and other people present at the POA
- Minimization of interference with POA activities

Elevation and location of an observation platform are critical to ensuring that MMOs can observe as far as possible, including harassment zones and shutdown zones, during pile installation and removal. Past monitoring efforts at the POA took place from a platform built on top of a cargo container or a platform raised by an industrial scissor lift (ICRC 2011, 2012). A similar raised, mobile observation platform will likely be used for the PCT Project. The MMOs will have no other construction-related tasks or responsibilities while conducting monitoring for marine mammals.

Trained MMOs will be responsible for monitoring the 100-meter shutdown zone, the Level A harassment zones, and the Level B harassment zone, as well as effectively documenting Level A and Level B take. They will also: (1) report on the frequency at which marine mammals are present in the project area; (2) report on behavior and group composition near the POA; (3) record all construction activities; and (4) report on observed reactions (changes in behavior or movement) of marine mammals during each sighting. Observers will monitor for marine mammals during all in-water pile installation and removal associated with the PCT Project. Observers will work in collaboration with the POA to immediately communicate the presence of marine mammals prior to or during pile installation or removal.

A report that includes data collected and summarized from all monitoring locations will be submitted to NMFS within 90 days of the completion of the marine mammal monitoring.

The marine mammal monitoring approach will be described in further detail in the Marine Mammal Monitoring and Mitigation Plan developed in coordination with NMFS (Appendix A).

13.2 Acoustic Measurements

Hydroacoustic monitoring for the PCT will take the form of a Monitoring Plan, the primary purpose of which will be to determine the effectiveness of the bubble curtain system and inform the process for obtaining Letters of Authorization under the MMPA during Phase 2 of the PAMP. A secondary purpose will be to determine empirical distances to the Level A injury and Level B disturbance zones for the PCT, which were estimated in the PCT IHA application (POA 2019) based on empirical measurements from the TPP in summer 2016.

Pile installation can cause elevated underwater noise levels, which have the potential to disturb or injure marine mammals. There is concern that the noise levels associated with pile installation for the PCT Project may affect marine mammals that occur within the zone of ensonification. The Monitoring Plan will be performed in compliance with MMPA and Endangered Species Act permitting requirements. Hydroacoustic data collection and analysis methods for the PCT Project will follow NMFS' guidance on hydroacoustic monitoring (NMFS 2012a, 2012b, 2012c).

For more details, see the Draft Acoustic Monitoring Plan (Appendix B).

14 Suggested Means of Coordination

To minimize the likelihood that impacts will occur to the species, stocks, and subsistence use of marine mammals, pile installation and removal associated with the PCT Project will be conducted in accordance with all federal, state, and local regulations. To further minimize potential impacts from the PCT Project, the POA will continue to cooperate with NMFS and other appropriate federal agencies (i.e., U.S. Fish and Wildlife Service, U.S. Coast Guard, JBER, U.S. Environmental Protection Agency, and USACE), and the State of Alaska. Potential impacts to subsistence use of marine mammals will be minimized through ongoing cooperation with Alaska Native leadership in Cook Inlet communities, as discussed in Section 12.

The POA will cooperate with other marine mammal monitoring and research programs taking place in Cook Inlet to coordinate research opportunities when feasible. The POA will also assess mitigation measures that can be implemented to eliminate or minimize any impacts from these activities. The POA will make available its field data and behavioral observations of marine mammals that occur in the project area during the construction of the PCT to NMFS. Results of monitoring efforts from the construction of the PCT will be provided to NMFS in a summary report within 90 days of the conclusion of monitoring. This information could be made available to regional, state, and federal resource agencies, universities, and other interested private parties upon written request to NMFS.

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Appendix A

Marine Mammal Monitoring and Mitigation Plan

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APPLICATION

Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Marine Mammal Monitoring and Mitigation Plan

Prepared for the

Port of Alaska

2000 Anchorage Port Road
Anchorage, Alaska 99501

October 15, 2019

CH2M, Inc.
Anchorage, Alaska

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Acronyms and Abbreviations

BA	Biological Assessment
dB	Decibels
DPS	Distinct Population Segment
ESA	Endangered Species Act
FR	*Federal Register*
HF	High Frequency
ICRC	Integrated Concepts and Research Corporation
IHA	Incidental Harassment Authorization
LF	Low Frequency
MF	Mid-Frequency
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
OW	Otariid in Water
PAMP	Port of Alaska Modernization Program
PCT	Petroleum and Cement Terminal
POA	Port of Alaska
PW	Phocid in Water
QA	Quality Assurance
QC	Quality Control
SSL	Sound Source Level
USACE	U.S. Army Corps of Engineers
USDOT	U.S. Department of Transportation
WSDOT	Washington State Department of Transportation

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1 Introduction

The Port of Alaska (POA) is requesting an Incidental Harassment Authorization (IHA) for the take of small numbers of marine mammals incidental to construction of the Petroleum and Cement Terminal (PCT) Project, at its existing port facility in Anchorage, Alaska. This Marine Mammal Monitoring and Mitigation Plan (Monitoring Plan) was prepared as an appendix to the request for an IHA under the Marine Mammal Protection Act (MMPA), and in support of the Biological Assessment (BA) for formal Section 7 consultation with the National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA). This Monitoring Plan incorporates NMFS' best practices and definitions for standardizing data collection and entry for marine mammal sightings, including the Cook Inlet beluga whale.

The PCT is part of an overall reconstruction plan for the POA, referred to as the Port of Alaska Modernization Program (PAMP). Located within the Municipality of Anchorage on Knik Arm in upper Cook Inlet, the existing infrastructure and support facilities were constructed largely in the 1960s. Port facilities are substantially past their design life, have degraded to levels of marginal safety, and are in many cases functionally obsolete, especially in regard to seismic design criteria and condition. The PAMP will include construction of new pile-supported wharves and trestles to the south and west of the existing terminals, with a planned design life of 75 years.

The PCT Project is expected to produce noise levels that could exceed Level A (injury) and Level B (disturbance) harassment thresholds established by NMFS for marine mammals under the MMPA (70 *Federal Register* [FR] 1871-1875). Level A harassment means any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment means any act of pursuit, torment, or annoyance that 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 that does not have the potential to injure a marine mammal or marine mammal stock in the wild.

Beluga whales (*Delphinapterus leucas*), harbor seals (*Phoca vitulina*), and harbor porpoises (*Phocoena phocoena*) may be encountered near the PCT Project. In addition, killer whales (*Orcinus orca*), humpback whales (*Megaptera novaeangliae*), and Steller sea lions (*Eumetopias jubatus*) may occur infrequently in northern Cook Inlet. A small number of Level B takes was requested for all six species of marine mammals, and a small number of Level A takes was also requested for harbor seals, harbor porpoises, and Steller sea lions. All marine mammals are protected under the MMPA; the Cook Inlet beluga whale, the Mexico Distinct Population Segment (DPS) of humpback whales, and the western DPS of Steller sea lions are also listed under the ESA.

The overall goal of the Monitoring Plan is to comply with the MMPA and ESA during in-water pile installation and removal associated with the PCT Project. Please refer to the IHA application for detailed information on the PCT Project, potential effects on marine mammals, and a complete list of mitigation measures.

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2 Marine Mammal Monitoring Overview

To minimize impacts of construction noise on marine mammals, Marine Mammal Observers (MMOs) will be on site during all in-water pile installation and removal associated with the PCT Project. MMOs will search for, monitor, document, and track marine mammals around and within the Level A and Level B harassment zones (Section 3.2.1).

The POA is planning for in-water pile installation and removal to occur from 01 April 2020 through 31 March 2021 for Phase 1, and a subsequent year for Phase 2, from 01 April 2021 through 31 March 2022. The number of days of PCT in-water pile installation and removal is estimated at 127 days for Phase 1 and 75 days for Phase 2. Each phase is anticipated to occur between April and November of 2020 and 2021, respectively. These dates are estimates and may shift as contracting details, starting dates, production rates, and other factors vary.

2.1 Marine Mammal Observer Qualifications and Training

All MMOs will undergo project-specific training, which will include training in monitoring, data collection, theodolite operation, and mitigation procedures specific to the PCT Project. This training will also include site-specific health and safety procedures, communication protocols, and supplemental training in marine mammal identification and data collection specific to the PCT Project. Training will include hands-on use of required field equipment to ensure that all equipment is working and MMOs know how to use the equipment.

All MMOs must be capable of spotting and identifying marine mammals and documenting applicable data during all types of weather, including rain, sleet, snow, and wind. At a minimum, all MMOs will have or meet the following qualifications:

- MMOs will be independent observers not engaged in construction activities.
- Visual acuity (correction is permissible) sufficient to allow detection and identification of marine mammals at the water's surface; use of binoculars may be necessary to correctly identify a sighting to species
- Demonstrated ability to conduct field observations and collect data according to assigned protocols (this may include academic training and/or previous field experience)
- Documented marine mammal monitoring experience or training, or an undergraduate degree in biological science or a related field
- Sufficient training, orientation, or experience with construction operations to provide for personal safety during observations
- Ability to communicate orally, by radio or in person, with project personnel about marine mammals observed in the area
- Experience or training in the use of a theodolite in order to track the movements of marine mammals
- Ability to collect the required marine mammal observation data as detailed in Section 3.5

A designated Lead MMO will always be on site and will remain responsible for implementing the Monitoring Plan for all in-water pile installation and removal for the PCT Project.

The Lead MMO must have education and experience that demonstrates his or her qualifications to serve as Lead MMO, including the following minimum requirements:

- Education in wildlife observation techniques from a university, college, or other formal education program
- Previous professional marine mammal observation experience

2.2 Roles and Responsibilities

The Monitoring Coordinator is the individual managing the entire marine mammal monitoring program under the Construction Contractor. A single Point of Contact (POC) will be identified by the Construction Contractor on a daily basis on both the MMO crew and construction crew to provide the lead authority. The single POC for the MMO crew will be the designated Lead MMO, and for the construction crew will be identified as the Construction Contractor POC. MMOs are responsible for understanding all project-specific MMPA and ESA requirements. When a marine mammal is sighted approaching or within a Level B or Level A harassment zone, the Lead MMO will contact the Construction Contractor POC to advise them on shutdown protocols to comply with MMPA and ESA requirements. The Construction Contractor POC will assess the in-water pile installation or removal, including safety considerations, to determine if a shutdown will occur immediately. See Section 3.2.2 for more information on shutdown procedures.

2.3 Communication Systems

A clear authorization and communication system will be in place to ensure that MMOs, hydroacoustic monitoring personnel (when applicable), and construction crews understand their roles and responsibilities before construction begins. The Construction Contractor POC will communicate to the Lead MMO the types and numbers of piles that will be installed on a daily basis. It is important that any changes be communicated from the Construction Contractor POC to the Lead MMO, as this influences the harassment zone sizes.

Each MMO will be trained and provided with reference materials (i.e., observation and communication protocol) to ensure standardized communication systems and accurate observations and data collection. All field personnel (MMOs, hydroacoustic, and construction) will communicate marine mammal sightings to ensure that field personnel are aware that marine mammals are in the area.

2.4 Equipment

The following equipment and information will be required on site for marine mammal monitoring:

- Portable radios for the MMOs to communicate with the Construction Contractor POC and other MMOs (if there are multiple stations)
- Cellular phones and phone numbers for all MMOs, the Monitoring Coordinator, and the Construction Contractor POC
- Daily tide tables
- Large aperture binoculars (25X or better)
- Hand-held binoculars (7X or better) with built-in rangefinder or reticles
- Theodolite for tracking marine mammals
- Electronic data collection system (e.g., Toughbook or iPad) and back-up paper forms
- Laminated copy of definitions for data collected
- Laminated, large (11- by 17-inch or similar) maps of the project area and monitoring zones

2.5 Observation Location(s)

Before the PCT Project commences, the Monitoring Coordinator, Construction Contractor POC, and Port Construction Manager will meet to determine the best vantage point practicable for the observation platform(s) for monitoring during in-water pile installation and removal. Considerations will include:

- Elevation of the observation platform, to maximize field of view and distance
- Ability to see Level A and Level B harassments zones as well as the 100-meter shutdown zone
- Ability to see the shoreline, along which beluga whales commonly travel
- Safety of the MMOs, construction crews, and other people present at the POA
- Minimizing interference with POA activities

Elevation and location of an observation platform are critical to ensuring that MMOs can observe as far as possible, including harassment zones and shutdown zones, during pile installation and removal. Past monitoring efforts at the POA took place from a platform built on top of a cargo container or a platform raised by an industrial scissor lift (ICRC 2011, 2012). A similar raised, mobile observation platform will likely be used for the PCT Project.

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3 Marine Mammal Monitoring and Mitigation

Four MMOs will work concurrently to provide full coverage for marine mammal monitoring in rotating shifts during in-water pile installation and removal during the PCT Project. MMOs will work in four-person teams to increase the probability of detecting marine mammals and to confirm sightings. Three MMOs will scan the Level A and Level B harassment zones surrounding in-water pile installation and removal for marine mammals by using large aperture binoculars (25X), hand-held binoculars (7X), and the naked eye (HDR 2011). Four MMOs will rotate through these three active monitoring methods roughly every 30 minutes to reduce eye strain and increase observer alertness. The fourth MMO will record data on the computer, a less-strenuous activity that will provide the opportunity for rest.

3.1 Pre-activity Monitoring and Startup Procedures

MMOs will begin observing for marine mammals within the Level A and Level B harassment zones for 30 minutes before a "soft start" or in-water pile installation or removal begins, or whenever a break in pile installation or removal of 30 minutes or longer occurs.

A ''soft start'' technique will be used at the beginning of impact pile installation to allow any marine mammal that may be in the immediate area to leave before pile driving reaches full energy. Soft starts will not be used for vibratory pile installation and removal. When the impact hammer is used, operators will provide an initial set of three strikes from the impact hammer at reduced energy, followed by a 30-second waiting period, then two subsequent three-strike sets.

If the Level A and Level B zones have been monitored continuously during impact installation of the day's first pile, and the MMOs have confirmed that no marine mammals are observed within the Level A and Level B zones, impact installation of the successive pile will begin without a soft start.

If a marine mammal for which take is **not authorized** is sighted within the Level A or Level B harassment zones, a soft start will not commence until the MMO has determined, through sighting or by waiting 15 minutes without resighting, that the animal(s) has moved outside of the Level A and Level B harassment zones.

If a marine mammal for which Level B take is **authorized** is present within the Level A harassment zone, ramping up will be delayed until the animal(s) leaves the Level A harassment zone. Activity will begin only after the MMO has determined, through sighting, that the animal(s) has moved outside the Level A harassment zone.

If a marine mammal for which Level B take is **authorized** is sighted within the Level B harassment zone after the 30-minute monitoring period but prior to soft start, the Contractor will either (1) begin soft start with documentation of take or (2) delay the soft start to avoid take of marine mammals. A soft start may occur whether a marine mammal enters the Level B zone from the Level A zone, or from outside the Project area.

If a marine mammal for which Level A take is **authorized** is sighted within the Level A harassment zone, a soft start will not commence until the MMO has determined, through sighting or by waiting 15 minutes without resighting, that the animal(s) has moved outside of the Level A harassment zone.

If the Level A harassment zones have been observed to be clear of marine mammals for 15 minutes, in-water pile installation or removal can commence and continue even if visibility becomes impaired within the Level B harassment zone.

The MMOs will document when monitoring begins, when they have communicated to the Construction Contractor POC that soft start can begin, and when soft start actually commences.

3.2 During Activity Monitoring and Shutdown Procedures

During pile installation or removal, MMOs will observe the Level A and Level B harassment zones for marine mammals. They will also observe around the outer edges of the harassment zones to determine whether marine mammals are approaching the harassment zones.

When a marine mammal is sighted, one MMO will be designated to continue tracking the individual or group and gathering focal-follow information throughout the harassment zones, while the other MMOs will continue to scan for additional groups of marine mammals. If multiple species of marine mammals are sighted, priority will be given to tracking beluga whales. Continual tracking of marine mammals will occur regardless of construction activities and will allow for MMOs to distinguish between single and multiple group sightings.

If the entire Level B harassment zone is not visible while in-water pile installation or removal continues, potential exposures will be extrapolated based upon the numbers of observed marine mammals by species and the percentage of the Level B harassment zone that was not visible.

3.2.1 Harassment and Shutdown Zones

Distances to the harassment thresholds, as defined by sound isopleths, vary by functional hearing group, pile size, duration of installation, and pile-installation method. Estimates of distances to the Level A and Level B harassment isopleths for the PCT Project are outlined in the IHA application. Table 3-1 and Table 3-2 provide distances to Level A and Level B harassment zones that will be used for the PCT Project. Figures illustrating the corresponding Level A and Level B harassment zones for the different numbers and types of piles in Table 3-1 and Table 3-2 can be found in Attachment A.

Table 3-1. Calculated Distances to Level A and Level B Harassment Isopleths for Installation and Removal of Permanent Piles during Phase 1

<table>
<tr><th colspan="3" rowspan="3">Activity</th><th rowspan="3">Piles installed per day</th><th colspan="5">Level A harassment zone (m)</th><th colspan="5">Level B harassment zone (m)</th></tr>
<tr><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th></tr>
<tr><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th></tr>
<tr><td rowspan="6">48” Loading Platform Installation</td><td rowspan="6">Impact</td><td rowspan="3">Bubble Curtain</td><td>1</td><td>655</td><td>34</td><td>766</td><td>376</td><td>36</td><td colspan="5" rowspan="3">629</td></tr>
<tr><td>2</td><td>989</td><td>51</td><td>1,156</td><td>567</td><td>55</td></tr>
<tr><td>3</td><td>1,258</td><td>65</td><td>1,470</td><td>721</td><td>70</td></tr>
<tr><td rowspan="3">Unattenuated</td><td>1</td><td>1,706</td><td>88</td><td>1,993</td><td>978</td><td>95</td><td colspan="5" rowspan="3">1,513</td></tr>
<tr><td>2</td><td>2,574</td><td>132</td><td>3,008</td><td>1,475</td><td>143</td></tr>
<tr><td>3</td><td>3,274</td><td>168</td><td>3,826</td><td>1,877</td><td>182</td></tr>
<tr><td rowspan="6">48” Access Trestle</td><td rowspan="6">Impact</td><td rowspan="3">Bubble Curtain</td><td>1</td><td>767</td><td>39</td><td>897</td><td>440</td><td>43</td><td colspan="5" rowspan="3">629</td></tr>
<tr><td>2</td><td>1,158</td><td>59</td><td>1,353</td><td>664</td><td>64</td></tr>
<tr><td>3</td><td>1,473</td><td>76</td><td>1,721</td><td>844</td><td>82</td></tr>
<tr><td rowspan="3">Unattenuated</td><td>1</td><td>1,997</td><td>102</td><td>2,334</td><td>1,145</td><td>111</td><td colspan="5" rowspan="3">1,513</td></tr>
<tr><td>2</td><td>3,014</td><td>155</td><td>3,521</td><td>1,727</td><td>168</td></tr>
<tr><td>3</td><td>3,833</td><td>197</td><td>4,479</td><td>2,197</td><td>213</td></tr>
</table>

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)				
				Cetaceans			Pinnipeds		Cetaceans			Pinnipeds	
				LF	MF	HF	PW	OW	LF	MF	HF	PW	OW
48" Loading Platform and Access Trestle Installation	Vibratory	**Bubble Curtain**	**1**	**5**	**1**	**7**	**3**	**0.3**	**2,247**				
		Unattenuated	1	12	1	18	8	1	5,967				
36" Temporary Access Work Trestle and Derrick Barge Vibratory Installation and Removal	Vibratory	**Bubble Curtain**	**3**	**12**	**1**	**17**	**8**	**1**	**1,699**				
		Unattenuated	3	32	3	45	20	2	4,514				
36" Temporary Access Work Trestle (restrikes)	Impact	**Bubble Curtain**	**1**	**45**	**2**	**52**	**26**	**2**	**296**				
			2	**68**	**3**	**79**	**39**	**4**					
			3	**86**	**4**	**101**	**49**	**5**					
		Unattenuated	3	224	11	262	128	12	713				
24" Temporary Construct-ion Work Trestle, Access Trestle Template, Access Float and Temporary Dolphins	Vibratory	**Bubble Curtain**	**4**	**7**	**1**	**10**	**4**	**0.4**	**846**				
		Unattenuated	4	19	2	27	12	1	2,247				
24" Temporary Construct-ion Work Trestle, Access Trestle Template, Installation and Removal, Plumb	Impact[a]	**Bubble Curtain**	**5**	77	4	90	44	4	**261**				
		Unattenuated	5	201	10	235	115	11	629				

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)				
				Cetaceans			Pinnipeds		Cetaceans			Pinnipeds	
				LF	MF	HF	PW	OW	LF	MF	HF	PW	OW
24” Temporary Dolphins, Installation and Removal, **battered**	Vibratory	Bubble Curtain	3	3	0.4	5	2	0.2	846				
		Unattenuated	**3**	**9**	**1**	**13**	**6**	**1**	**2,247**				

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; m = meters.

Table 3-2. Calculated Distances to Level A and Level B Harassment Isopleths for Installation and Removal of Temporary Piles during Phase 2

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)				
				Cetaceans			Pinnipeds		Cetaceans			Pinnipeds	
				LF	MF	HF	PW	OW	LF	MF	HF	PW	OW
144" Breasting and Mooring Dolphin Installation	Impact	**Bubble Curtain**	**0.3**	**2,286**	**117**	**2,672**	**1,311**	**127**	**1,945**				
			0.7	**3,781**	**194**	**4,418**	**2,167**	**210**					
		Unattenuated	0.3	5,951	305	6,954	3,411	331	4,681				
			0.7	9,840	505	11,498	5,640	547					
	Vibratory	**Bubble Curtain**	**1**	**24**	**3**	**34**	**15**	**1**	**9,069**				
		Unattenuated	1	73	8	104	47	4	24,089				
36” Dolphin Template Piles and Derrick Barge Vibratory Installation and Removal	Vibratory	**Bubble Curtain**	**4**	12	1	17	8	1	**1,699**				
		Unattenuated	4	38	4	54	24	2	4,514				
24” Temporary Dolphins Vibratory Installation and Removal, plumb	Vibratory	**Bubble Curtain**	**3**	**3**	**0**	**5**	**2**	**0**	**846**				
		Unattenuated	3	9	1	13	6	1	2,247				

Activity			Piles installed per day	Level A harassment zone (m)					Level B harassment zone (m)				
				Cetaceans			Pinnipeds		Cetaceans			Pinnipeds	
				LF	MF	HF	PW	OW	LF	MF	HF	PW	OW
24" Temporary Dolphins Vibratory Installation and Removal, battered	Vibratory	Bubble Curtain	3	3	0	5	2	0	846				
		Unattenuated	**3**	**9**	**1**	**13**	**6**	**1**	**2,247**				

Note: Bold text corresponds to most likely construction scenario. LF = low frequency; MF = mid-frequency; HF = high frequency; PW = phocid in water; OW = otariid in water; m = meters.

During some phases of construction, three hammers could operate within a day and two could operate simultaneously for brief periods of time within a day. Construction sequencing for the PCT will not be known with certainty until construction begins and progresses. At this stage of project development, it is anticipated that the most likely combinations of piles that could be installed within a day include:

- Vibratory hammer installation of 24-inch piles and impact hammer installation of 48-inch trestle or loading platform piles, and
- Vibratory hammer installation of 36-inch piles and impact hammer installation of 48-inch trestle or loading platform piles.

It is not expected that two vibratory hammers will be operating at the same time.

NMFS (2018) handles overlapping sound fields created by use of more than one hammer differently for impact and vibratory hammers. Based on the NMFS (2018) guidance for use of two impact hammers simultaneously, it is unlikely that the two hammers would operate in synchrony, and therefore, the sound pressure levels will not be adjusted regardless of the distance between the hammers. In this case, each impact hammer will be considered to have its own independent harassment zone.

Based on the NMFS (2018) guidance, simultaneous use of two vibratory hammers can create overlapping sound fields, resulting in additive effects of sound from the different hammers under certain conditions. In this case, although the sound from two sources near the same location results in louder sound levels than a single source alone, the sound levels cannot be added by standard addition because the decibel is measured on a logarithmic scale. For example, two sounds of equal level (plus or minus 1 decibel [dB]) combine to raise the sound level by 3 dB. However, if two sounds differ by more than 10 dB, there is no combined increase in the sound level; the higher output covers any other sound (Table 3-3). This approach was used by the Washington State Department of Transportation (WSDOT) in assessment of potential impacts from sound associated with construction of the Seattle Multimodal Construction Project (82 FR 15497) and builds upon work by the U.S. Department of Transportation (USDOT; 1995) and Kinsler (2000).

For marine mammal monitoring purposes, if the isopleth from one sound source encompasses a second sound source over a free sound field (i.e., no landmass separating the sound sources), then the sources are considered close enough to be a "combined sound source" and their sound levels are added (Table 3-3; NMFS 2018) to determine the sound isopleth. The resulting isopleth is centered on the "combined source," which is the geometric centroid of the polygon that is formed by the sound sources.

During simultaneous use of an impact hammer and a vibratory hammer, the Level A zones for the impact hammer and the Level B zone for the vibratory hammer will be implemented.

Table 3-3. Rules for Combining Sound Levels Generated during Pile Installation and Removal

Species or DPS	Difference in SSL	Level A Zones	Level B Zone
Vibratory, Impact	Any	Use impact zones	Use vibratory zone
Impact, Impact	Any	Use zones for each pile size and number of strikes	Use zone for each pile size
Vibratory, Vibratory	0 or 1 dB	Add 3 dB to the higher source level	Add 3 dB to the higher source level
	2 or 3 dB	Add 2 dB to the higher source level	Add 2 dB to the higher source level
	4 to 9 dB	Add 1 dB to the higher source level	Add 1 dB to the higher source level
	10 dB or more	Add 0 dB to the higher source level	Add 0 dB to the higher source level

Source: Modified from USDOT 1995, WSDOT 2018, and NMFS 2018b

The POA is proposing a 100-meter “shutdown” zone for all marine mammals during pile installation and removal. Level A take is being requested for harbor porpoises, Steller sea lions, and harbor seals; however, this shutdown zone will avoid exposure of marine mammals to sound levels within the 100-meter zone. The 100-meter shutdown zone will be implemented to avoid Level A take of beluga whales and killer whales. Although every effort will be made to shut down before marine mammals enter the 100-meter zone, if the Level A isopleth for a species is smaller than 100 meters, Level A take of that species would not occur unless individuals move across their respective Level A isopleths as defined in Table 3-1 and Table 3-2. For some species and pile configurations, the Level A harassment zone will be greater than 100 meters, and will be implemented as calculated in Table 3-3.

3.2.2 Shutdown Procedures

If a marine mammal is traveling along a trajectory that could take it into the Level B harassment zone, the Lead MMO will notify the Construction Contractor POC, who will decide to either (1) immediately shut down all in-water pile installation or removal before the marine mammal enters the Level B harassment zone, thereby avoiding a take (shutdown will occur for all marine mammals for which Level B take was not authorized under the IHA); or (2) document the marine mammal as a take upon its entry into the Level B harassment zone. For safety and operational reasons, the immediate shutdown of in-water pile installation or removal may not be possible. The MMOs will document the reason behind each shutdown or non-shutdown decision.

If the Construction Contractor POC decides to continue pile installation or removal while a marine mammal is within the Level B harassment zone, that pile segment will be completed without cessation, unless the animal approaches and is likely to enter the Level A harassment zone. At that point, the Construction Contractor POC will immediately shut down all in-water pile installation and removal before the marine mammal enters the Level A harassment zone, thereby avoiding Level A take.

In addition, in-water pile installation and removal will shut down immediately for all marine mammals approaching the 100-meter shutdown zone. Although every effort will be made to shut down before marine mammals enter the 100-meter shutdown zone, if the Level A isopleth for a species is smaller than 100 meters, take of that species would not occur unless individuals move across their respective Level A isopleths as defined in Table 3-3. The MMOs will determine when a marine mammal(s) has left the harassment zone or has not been resighted for a period of 15 minutes, and will determine when soft start procedures and pile installation or removal may recommence.

Pile installation and removal will take place only when the Level A harassment zones can be adequately monitored. If the Level A zone cannot be seen in its entirety, pile installation and removal will stop until visibility is restored.

To avoid the potential for collision with a marine mammal during in-water work involving use of vessels (e.g., barges, tugboats, work boats, and skiffs), if a marine mammal approaches within 50 meters, operations shall cease and vessels shall reduce speed to the minimum level required to maintain steerage and safe working conditions (IHA Section, Mitigation Measure 11).

The Lead MMO and the Port Construction Manager will maintain a running tally of all takes that occur for each species. If the maximum authorized number of takes is reached or exceeded for the authorized period, in-water pile installation or removal will be shut down immediately. In addition, NMFS will be notified immediately and a revised plan will be developed before in-water pile installation or removal is resumed.

3.3 Post-activity Monitoring

Monitoring of the Level A and Level B harassment zones will continue during pile installation and removal. Once pile installation and removal are completed for the day, marine mammal observations will cease. Data forms should indicate whether the marine mammal(s) were still present in the area when marine mammal monitoring was completed.

3.4 Project Vessels

To avoid the potential for collision with a marine mammal during in-water work involving use of vessels (e.g., barges, tugboats, work boats, and skiffs), if a marine mammal approaches within 50 meters, vessels shall reduce speed to the minimum level required to maintain steerage and safe working conditions.

3.5 Data Collection

Data regarding environmental conditions, marine mammal sightings, communication with the Construction Contractor POC, and in-water project activities will be collected electronically through a computerized software system (i.e., Toughbook or iPad). Hardcopy paper forms will be available in case there are technical difficulties with equipment. If data are collected on paper forms, they will consist of the same variables that are collected electronically, and will include a map of the project site (Attachment B). Data entry will be checked for quality assurance and quality control by the Lead MMO on a daily basis. As previously stated, NMFS data collection best practices and definitions for standardizing data collection and entry for Cook Inlet beluga whale sightings have been incorporated into this Monitoring Plan. Because other marine mammals besides beluga whales are likely to be sighted during the PCT Project, definitions are expanded upon to include behaviors from all marine mammal species.

3.5.1 Environmental Conditions, Project Activities, and Communication

The MMOs will document monitoring efforts, environmental conditions, types of project activities, and any communications between MMOs, hydroacoustic personnel, and construction personnel. MMOs will document the start and stop times of all monitoring efforts. Environmental conditions will be documented at the beginning and end of every monitoring period and every half hour, or as conditions change. Data collected will include MMO names, location of the observation station, time and date of the observation, weather conditions, air temperature, sea state, cloud cover, visibility, glare, tide, and ice coverage (if applicable). See Table 3-4 for more information on each of these attributes.

The MMOs will document project activities, including size of pile, method of pile installation, and whether a bubble curtain was used, as well as the time of startup (or soft start) and shutdown. Pile installation and removal may be halted for a few hours or a full day for the addition of pile sections or to accommodate welding or inspections. All shutdowns of in-water pile installation and removal will be documented, including the reason for each shutdown. MMOs will also document other, non-project-related activities that could disturb marine mammals in the area, such as the presence of vessels or aircraft. The Lead MMO, the hydroacoustic monitoring crew (when applicable), and the Construction Contractor POC will communicate information regarding startups, shutdowns, and marine mammal sightings. MMOs will maintain a log of all communications.

Table 3-4. Environmental, Project Activities, and Communication Data Attributes

Data Attribute	Attribute Definition and Units Collected
Monitoring effort (Start & End Times)	Format 24-hour clock. This covers the entire amount of monitoring in a given day. If there is a break in the middle of the day when monitoring does not occur, the end time should be recorded. After the break, a new data sheet should be used to record the new monitoring effort start and end times.
Observers' names	Provide the full names of the MMOs.
Environmental Conditions (collected every 30 minutes or when conditions change)	
Overall conditions	Scale 1 to 10. 1= poor, 5 = moderate, 10 = excellent
Weather conditions	Sunny (S), partly cloudy (PC), light rain (LR), steady rain (SR), fog (F), overcast (OC), light snow (LS), snow (SN)
Light conditions	Light, twilight, dark
Air temperature	Celsius
Wind speed	Knots
Wind direction	From the north (N), northeast (NE), east (E), southeast (SE), south (S), southwest (SW), west (W), northwest (NW)
Sea state	(0) Mirror-like, calm; (1) ripples (up to 4 inches) without foam crests; (2) small wavelets (up to 8 inches); (3) large wavelets (up to 2 feet), perhaps scattered white horses; (4) small waves (up to 3 feet), fairly frequent white horses; (5) moderate waves (up to 6 feet)
Cloud cover	0–100%. Percentage of cloud cover
Visibility	Kilometers. Maximum distance at which a marine mammal could be sighted
Glare	0–100%. Percentage of water obstructed by glare and grid cells affected by glare or the direction of glare
Tide	Predicted hourly data information gathered from National Oceanic and Atmospheric Administration will be available on-site and reported in the 90-Day Technical Report
Ice coverage	0–100%. Percentage of ice cover and type of ice (no ice present, new, brash, or pancake ice and floes)
Other activity	Number, type, and general location of vessels or other sources of in-water disturbance
Project and Communication Activities	
Time of communication or project activity	Time that in-water project activities and all communications between MMOs and construction crews take place
Type of project activity and duration	Soft start, shutdown, impact pile installation, vibratory pile installation or removal, and sound attenuation method used. If shutdown occurs, document the reason for the shutdown.
Use of a bubble curtain and type	Type of bubble curtain; times it is turned on and off
Individuals communicating	Names of individuals involved in any communication
Communication	Information communicated between the Lead MMO and Construction Contractor POC

3.5.2 Sightings

All marine mammals observed will be documented. The data collected will include a unique group identifier specific to that day, start and end times of the sighting, species sighted, number of individuals (group size), age class, color classification (only for beluga whales), behavior and movement, distance at first observation, closest observed distance from project activities, type of in-water project activity at the time of sighting, and whether and when pile installation or removal was stopped in response to the sighting (Table 3-5). The MMO will also note any observed behavior changes that may be due to project activities.

A color classification system will be used for beluga whales only. Beluga whales will be documented as white, gray, dark gray calf, or dark gray neonate. This color classification will help estimate the age class of each animal. Adults are typically white, juveniles are generally gray, and calves/neonates are dark gray (Table 3-5); however, the age at which a beluga whale's color matures to white is variable. The proximity of calves to the mother will also be documented. Calves, especially neonates, typically remain in direct contact with the mother. When known, sex and age classes for all other marine mammals will be documented.

The use of a surveyor's theodolite will be the primary method to track marine mammals once they have been observed. The theodolite will be connected directly to the electronic data collection application or software system. The software system will use the data collected (horizontal and vertical angles to each individual or group of marine mammals) from the theodolite to determine the distance between the marine mammals and the project activity, and their positions relative to the Level A and Level B harassment zones. The software system will also have the ability to determine the geographic location of a group of marine mammals by entering the reticles and bearing, to be used as a backup if the theodolite is malfunctioning. The MMOs will continue to track or focal-follow the marine mammal's movements using the theodolite during the entire sighting period and while the marine mammals remain within the harassment zones. Locations should be measured every 5 minutes or when the animal's direction of movement or behavior changes.

The MMO will also track the marine mammals' behavior with every sighting of the group (Table 3-6), including any reactions caused by PCT Project activities or other human activities in the area. Potential indicators of negative responses to noise include an individual or group approaching and then leaving, changes in swimming speed or direction, and abrupt dives or dispersal (Kendall 2010). Any other activity to which the marine mammal could be responding will also be documented when possible.

Hardcopy data forms may be used as a backup to document and track marine mammals if there are equipment difficulties. The use of a 500-meter by 500-meter grid system to track marine mammals is consistent with previous POA monitoring programs. Tracking marine mammals using the theodolite is the preferred method, because it is more accurate than the grid system and eliminates manual data entry. If the grid system is necessary, MMOs will use binoculars, rangefinders, and landmarks to determine marine mammal locations. The MMO will use a map overlain with a 500-meter by 500-meter grid and the harassment zones for the specific location. The MMO will draw the location of the initial and last sightings, the point of closest approach, and a line to show the path of the animal(s) during the sighting to track marine mammals. The 500-meter by 500-meter grid may also be placed over theodolite tracks during data post-processing and analysis for consistency with previous monitoring programs.

When marine mammals are sighted, MMOs should delegate responsibilities so that one or more MMOs continue to scan the water to identify other marine mammals potentially entering the area, while another MMO continues to monitor and track the first sighting.

Table 3-5. Marine Mammal Observation Data Attributes

Data Attribute	Attribute Definition and Units Collected
Marine Mammal Sighting Data	
Group identification code	Each group of marine mammals will be given a unique group identification code. This group identification code is **not species specific**. This identifier can also be used to identify a group whose location, behaviors, and other variables have changed, requiring the use of multiple datasheets.
Time of initial and last sighting	Time the group is initially sighted and last sighted
Time animals entered and exited harassment zones	Time the group entered and exited harassment zones, if applicable
Species observed	Identify species observed: beluga whale, harbor seal, harbor porpoise, Steller sea lion, killer whale, humpback whale, or other species
Sighting cue	First observation behavior or body part: head, fluke, dorsal fin, body, splash, blow, birds feeding, porpoise, or other
Group size	Minimum and maximum number of animals counted; record the count the MMO believes to be the most accurate
Color classification	Beluga whale color classifications: ***White*** - Large, bright white to dull white ***Gray*** - Large (larger than calves), light to medium gray ***Dark gray*** - Calf - Dark gray, relatively small (<2/3 the total length of white belugas), almost always swimming within 1 body length of larger whale Neonate - Newborns (estimated to be hours to days old, based on extremely small size (~1.5 m [5 ft]), a wrinkled appearance due to the presence of fetal folds, and uncoordinated swimming and surfacing patterns ***Unknown color*** - Any beluga not confidently identified in above categories
Sex and age, if possible	Generally, it will be difficult to make this determination; however, sometimes numbers of females with pups or calves can be determined.
Initial and final heading	Cardinal direction animals are headed during initial and last sightings
General pace	Sedate, moderate, or vigorous
Tracking movement and theodolite readings	The movements and changes in locations should be documented for each sighting, including the horizontal and vertical angles used to determine location and distance from in-water project activities
Distances from marine mammal to in-water project activities and observation station	Approximate distance in meters or kilometers from a marine mammal to in-water project activities when initially sighted, at closest approach to activities, and at final sighting
In-water project activities at time of sighting	Type of project activities occurring at time of sighting; indicate shutdown times for pile installation or removal, if shutdown occurs
Other activities at time of sighting	Description of nearby activities occurring at time of sighting, such as presence, number, and activity of vessels nearby
Behavior	Indicate primary and secondary behaviors (see Table 3-6). Primary behavior is the behavior most commonly exhibited by the group; secondary behavior is the next most commonly exhibited behavior of the group
Change in behavior	Describe previous and new behavior and whether the change in behavior is correlated with project activities; record time

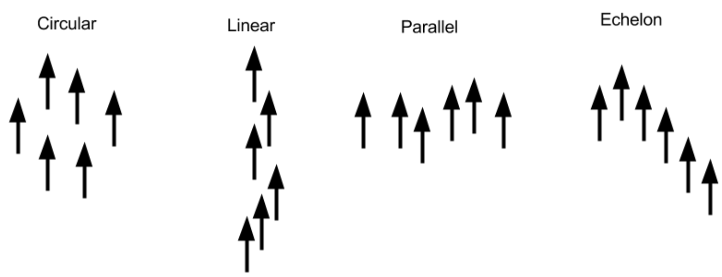
Data Attribute	Attribute Definition and Units Collected
Formation (for beluga whales only)	The formation of the group references how the individual beluga whales are distributed within the group. Enter the formation code that best reflects the distribution pattern of the group: **Circular** (C) – arranged in a circular group while moving in one direction **Parallel** (P) – alongside each other, spread perpendicular to direction of movement **Linear** (L) – forming a line, spread along direction of movement **Echelon** (E) – Arranged diagonally, each beluga whale to the side and behind beluga ahead of it; also includes "V" formation **No Formation** (NF) – Random or un-patterned formation 
Spread (for beluga whales only)	The spread of the whales is defined as the mean distance between beluga whales in body lengths (e.g., a spread of 2 indicates that the whales are spaced out, on average, 2 body lengths apart). This may be hard to estimate and may change frequently; MMOs should do their best to choose a representative integer for each sighting.
Number of animals taken	Indicate the number of animals potentially exposed to Level A and Level B harassment during the sighting

Table 3-6. Behavior Definitions

Activity	Code	Definition
Avoiding predation	AP	Moving with speed and/or abrupt changes in direction in response to an observed predator
Bubbling	BU	Producing many bubbles while submerged, not including normal subsurface exhalation associated with surfacing
Breach	B	Cetacean leaping or jumping clear of the water
Calving/Birthing	CS	Provide detailed comments to justify use of this code
Diving	D	Moving downward through the water column (rapidly or slowly), often showing tail fluke or hind flippers before dive
Feeding (observed)	FO	Observed with prey in mouth
Feeding (suspected)	FS	Diving, chasing, or pursuing prey or lunging, which suggest foraging. Could also be suggested by proxy events (e.g., jumping fish, associating birds and/or seals, etc.).
Mating suspected	MS	Two or more cetaceans or pinnipeds swimming in ventral-to-ventral contact slowly in same direction or rolling around in one place
Milling	M	Moving in a non-linear, weaving or circular pattern within an area
Porpoising	P	A cetacean or pinniped making low, arching leaps as it travels rapidly near the surface

Activity	Code	Definition
Resting	R	Floating at or near surface, with little or no movement for several minutes or more with no other suspected behavior
Side scanning	SS	Cetacean swimming (often very slowly) at the surface with lateral aspect (pectoral flipper, tail fluke, or side surface of body) visible, often for 30 seconds. May be followed by explosive prey pursuit.
Sink	SI	Seal sinks straight back down underwater, hind flippers first, with upright posture
Snorkeling	SN	Surfacing showing a low profile, with only blowhole, melon, and small portion of dorsal just posterior to blowhole visible. Pinnipeds would have nose and head skimming the water surface.
Socializing	S	Interacting with other cetaceans or pinnipeds, indicated by milling, bubbling, tail slapping, physical contact, or audible vocalizations
Spyhopping	SH	Holding body vertically with head out of water for several seconds or more
Startling	ST	Rapidly changing behavior, dispersing, or travelling that indicates a response to external event (not including avoiding predation)
Tail slapping	TS	Hitting tail fluke vigorously against water surface, producing a splash
Tail waving	TW	Holding body vertically with tail out of water for several seconds or more, often slowly waving tail, but not tail slapping
Travelling	T	Moving in a linear or near-linear direction without interruption
Vocalizing	V	Snorting, whistling, or chirping
Other	O	Unclassified behavior - must provide a comment
Unknown	U	Behavior indistinguishable due to monitoring conditions and/or lack of ability to watch whale for length of time to determine - no comment is necessary

3.5.3 Quality Assurance (QA) and Quality Control (QC)

Electronic data collection or data sheets will be QA/QC'd by the Lead MMO at the end of each monitoring day. No cells or information will be left blank. If information is not available or not applicable, the field will be indicated with an "NA" or dash. The data will also be QA/QC'd once it is entered into the monitoring data collection system (Section 3.5.4).

3.5.4 Marine Mammal Monitoring Database

All marine mammal monitoring data collected will be stored in a database. The database will be set up and structured for easy access and management of data, and will be used to develop the daily, monthly and final marine mammal monitoring reports (Section 4.3).

4 Reporting

4.1 Daily Reports

The Contractor Project Manager will provide a daily monitoring summary to the Port Construction Manager that will include a summary of marine mammals sighted and a copy of all data collected.

4.2 Monthly Reports

Monthly reports will be submitted to NMFS' MMPA office for all months in which in-water pile installation and removal occurs. Each monthly report will contain and summarize the following information:

- Monitoring effort (date, start time, end time, duration)
- Summary of environmental conditions
- Marine mammal sightings (date; sighting start and end times; duration of sighting; species; group size; age class or color classification; and behaviors, including any observed behaviors correlated with project activities or underwater sound levels)
- Marine mammal potential exposures (takes) by species
- In-water activities before and during marine mammal sighting
- Project shutdowns (date, start time, end time, duration, and reason for shutdown)

4.3 Draft and Final Technical Reports

A draft report, including data collected and summarized from all monitoring locations, will be submitted to NMFS' MMPA program within 90 days of the completion of monitoring efforts. A final marine mammal monitoring report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS. The Final Technical Report should include all information required for monthly reports (Section 4.2), plus the following information:

- Number of days of observations
- Lengths of observation periods
- Locations of observation station(s) used and dates of when each location was used
- Numbers, species, dates, group sizes, and locations of marine mammals observed
- Distances to marine mammal sightings, including closest approach to construction activities
- Descriptions of any observable marine mammal behavior in the Level A and Level B harassment zones
- Times of shutdown events, including when work was stopped and resumed due to the presence of marine mammals or other reasons
- Descriptions of the type and duration of any pile installation work occurring and soft start procedures used while marine mammals were being observed
- Details of all shutdown events, and whether they were due to presence of marine mammals, inability to clear the hazard area due to low visibility, or other reasons
- Tables, text, and maps to clarify observations

4.4 Notification of Injured or Dead Marine Mammals

In the unanticipated event that the **specified activity (pile installation and removal) clearly causes the take** of a marine mammal for which authorization has not been granted, such as a serious injury or mortality, the POA will immediately cease **pile installation and removal** and report the incident to the Office of Protected Resources (301-427-8401), NMFS, and the Alaska Regional Stranding Coordinator (907-271-1332), NMFS.

The report will include the following information:

- Time, date, and location (latitude/longitude) of the incident
- Detailed description of the incident
- Description of vessel involved (if applicable), including the name, type of vessel, and vessel speed before and during the incident
- Status of all sound source use in the 24 hours preceding the incident
- Environmental conditions (wind speed and direction, wave height, cloud cover, and visibility)
- Description of marine mammal observations in the 24 hours preceding the incident
- Species identification, description, and fate of animal(s) involved
- Photographs or video footage of animals or equipment (if available)

Pile installation and removal shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with the POA to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. The POA may not resume pile installation and removal until notified by NMFS' MMPA program via letter, email, or telephone.

In the event that the POA discovers an injured or dead marine mammal and the Lead MMO determines that the **cause of the injury or death is unknown**, the POA will immediately report the incident to Office of Protected Resources (301-427-8401), NMFS, and the Alaska Regional Stranding Coordinator (907-271-1332), NMFS.

The report will include any applicable information listed above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS would work with the POA to determine whether modifications to the activities are appropriate.

5 References

HDR, Inc. 2011. *Knik Arm Crossing Proof of Concept Study*. Prepared for Knik Arm Bridge and Toll Authority by HDR Alaska. December 2011.

ICRC (Integrated Concepts & Research Corporation). 2011. *2010 Annual marine mammal monitoring report*. Construction and Scientific Marine Mammal Monitoring Associated with the Port of Anchorage Marine Terminal Redevelopment Project, in accordance with the USACE 404/10 Permit and the NMFS 2010-2011 Letter of Authorization. Prepared for U.S. Department of Transportation, Maritime Administration, Washington, DC; Port of Anchorage, Anchorage, AK, by Integrated Concepts and Research Corporation, Anchorage, AK.

———. 2012. *2011 Annual marine mammal monitoring report*. Construction and Scientific Marine Mammal Monitoring Associated with the Port of Anchorage Marine Terminal Redevelopment Project, in accordance with the Letter of Authorization issued by the National Marine Fisheries for July 15, 2011, through July 14, 2012. Prepared for the U.S. Department of Transportation, Maritime Administration, Washington, DC; Port of Anchorage, Anchorage, AK, by Integrated Concepts and Research Corporation, Anchorage, AK.

Kendall, L.S. 2010. *Construction impacts on the Cook Inlet beluga whale (*Delphinapterus leucas*) at the Port of Anchorage Marine Terminal Redevelopment Project*. Master's thesis, Alaska Pacific University.

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Attachment A

Level A and Level B Harassment Zones

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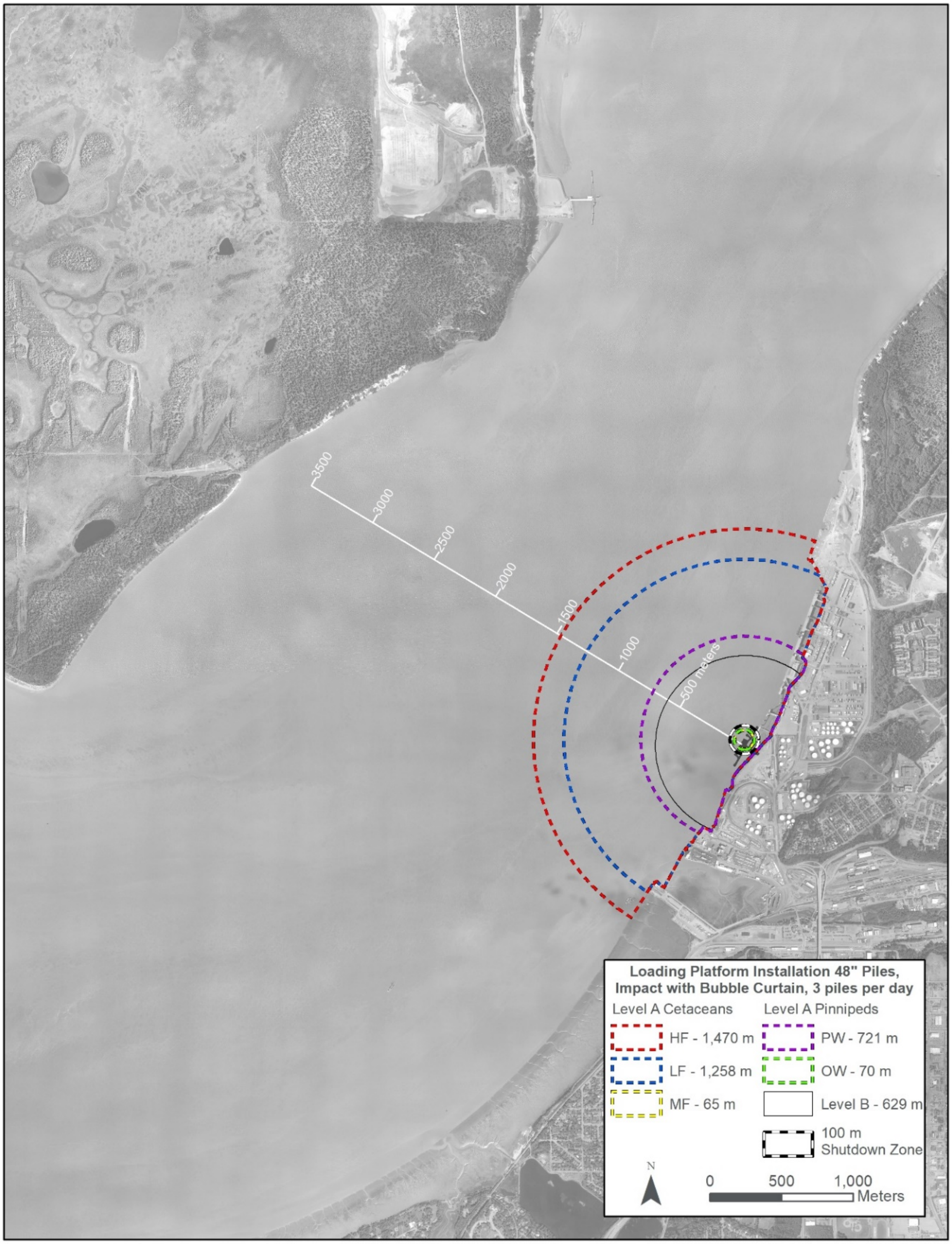

Figure A-1. Level A and Level B Harassment Isopleths during Impact Installation with a Bubble Curtain of 48-inch Loading Platform Piles at an Installation Rate of Three Piles per Day

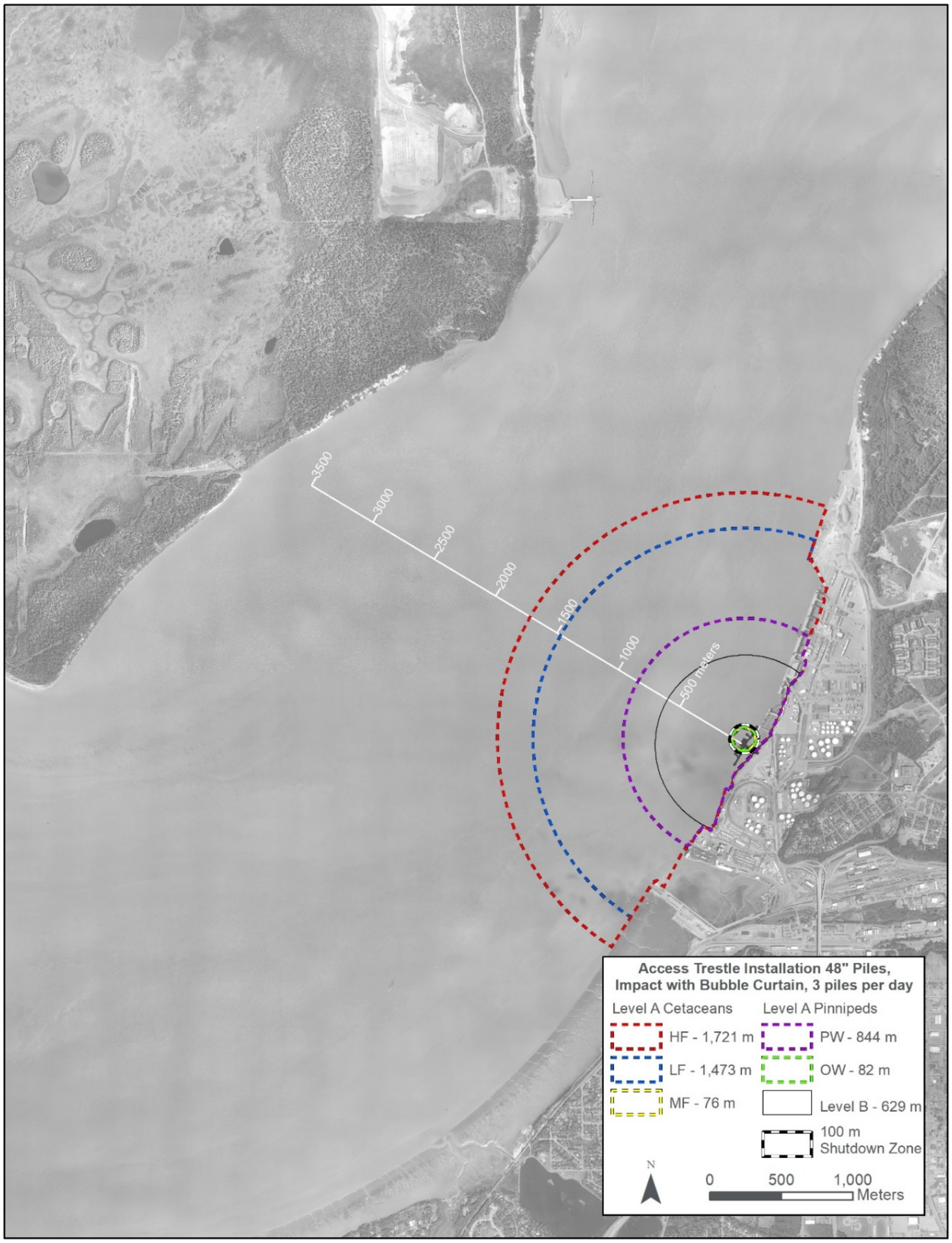

Figure A-2. Level A and Level B Harassment Isopleths during Impact Installation with a Bubble Curtain of 48-inch Access Trestle Dolphins at an Installation Rate of Three Piles per Day

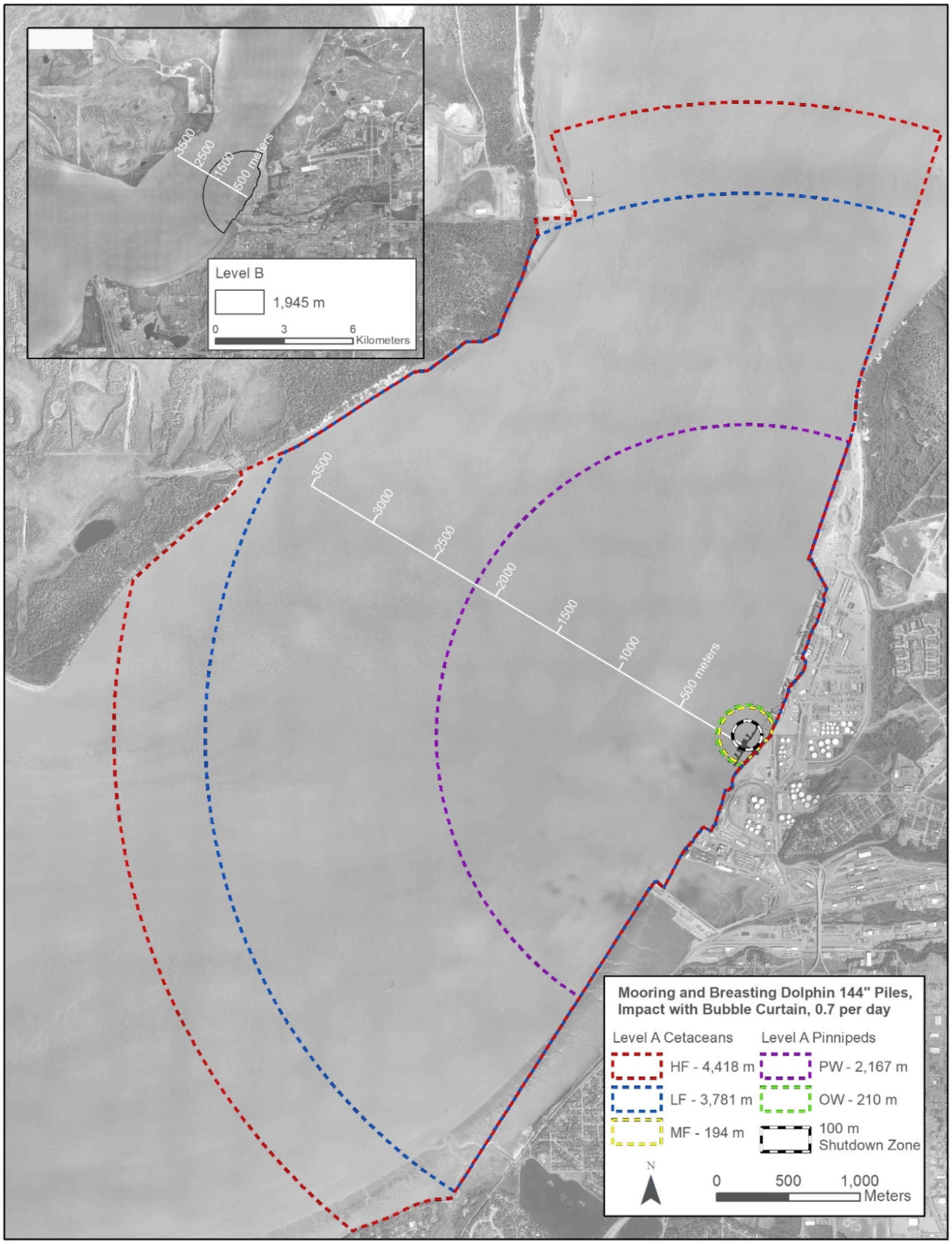

Figure A-3. Level A and Level B Harassment Isopleths during Impact Installation with a Bubble Curtain of 144-inch Mooring and Breasting Dolphin Piles at an Installation Rate of 0.7 Pile per Day

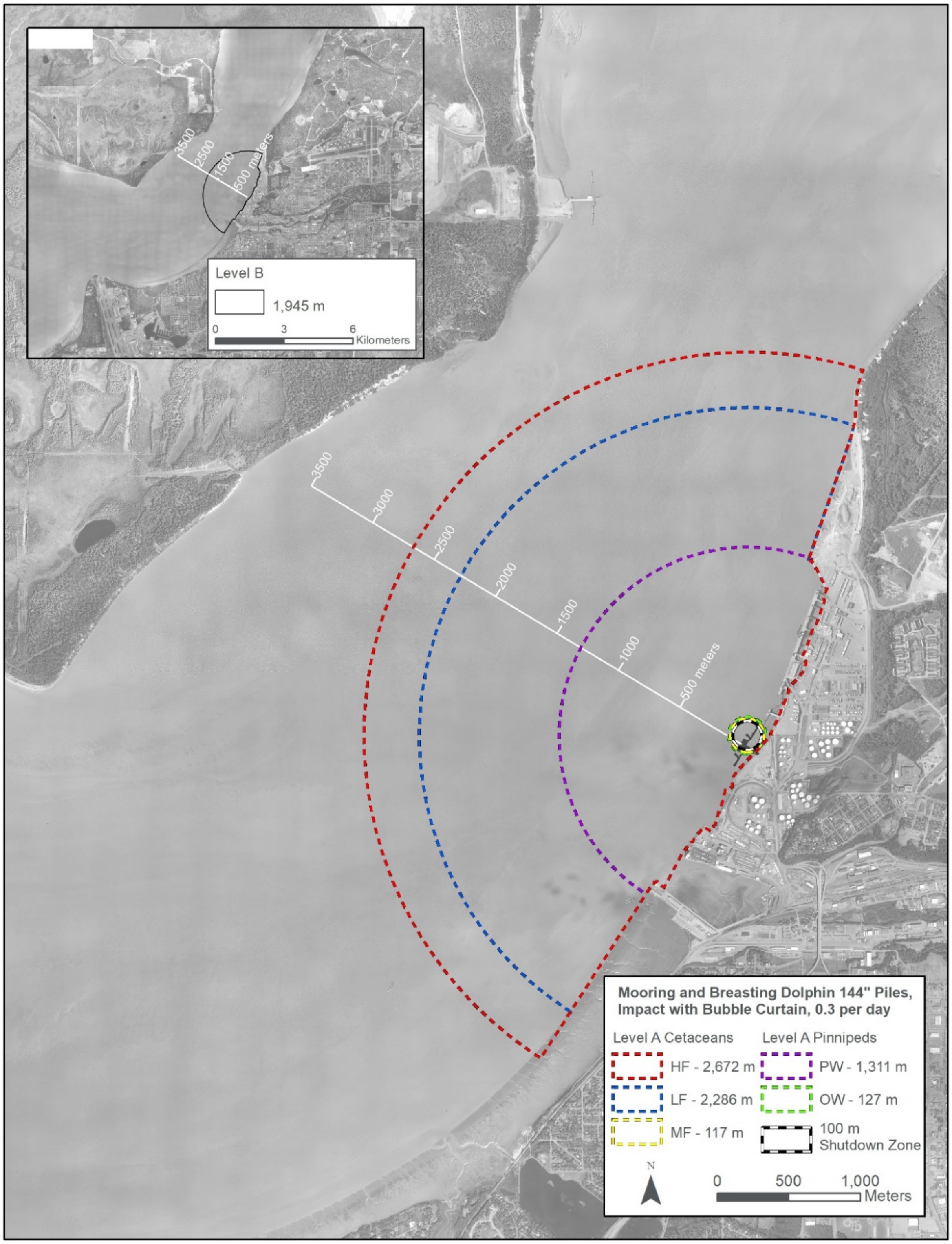

Figure A-4. Level A and Level B Harassment Isopleths during Impact Installation with a Bubble Curtain of 144-inch Mooring and Breasting Dolphin Piles at an Installation Rate of 0.3 Pile per Day

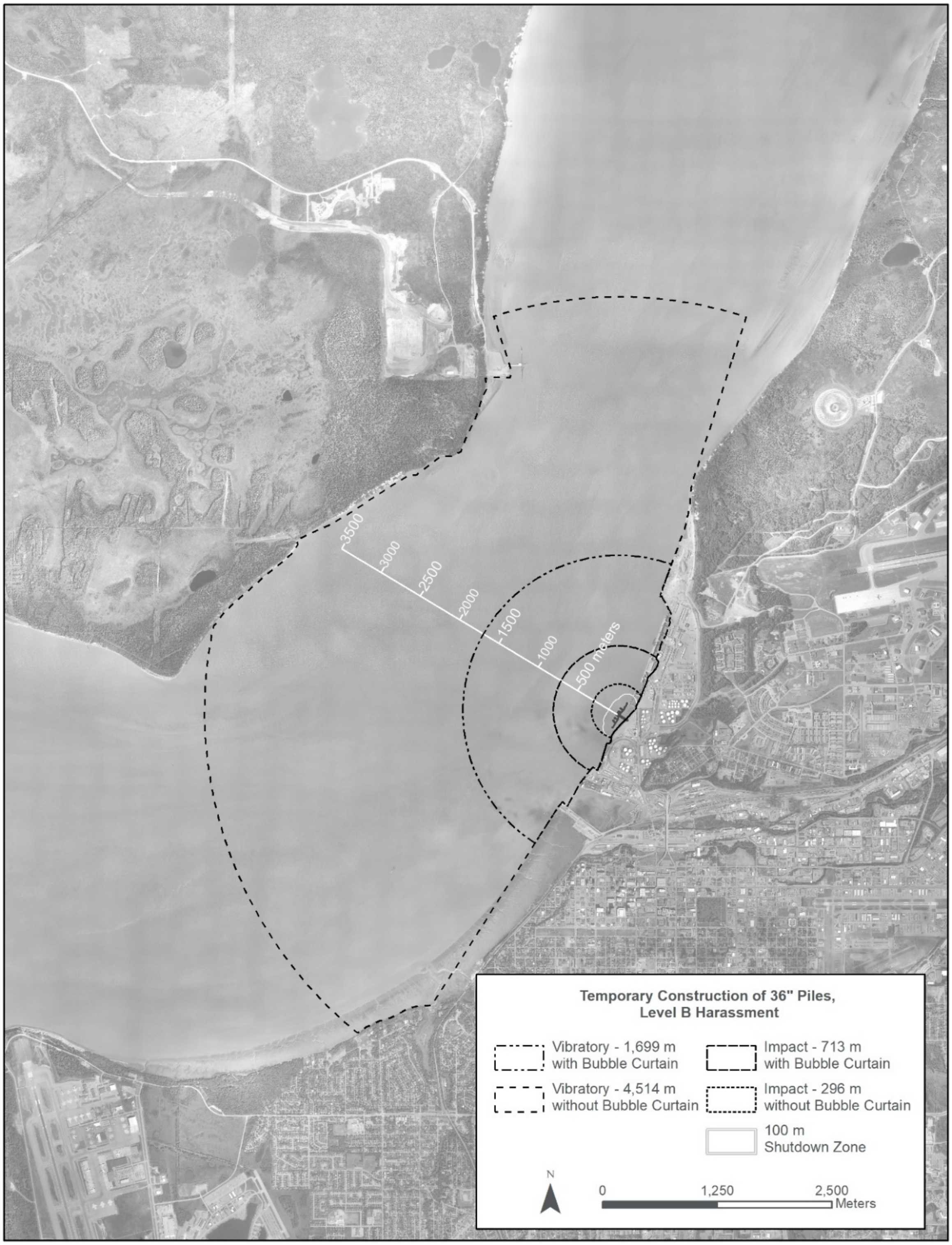

Figure A-5. Level B Harassment Isopleths during Vibratory and Impact Installation and Removal of 36- inch Temporary Construction Piles

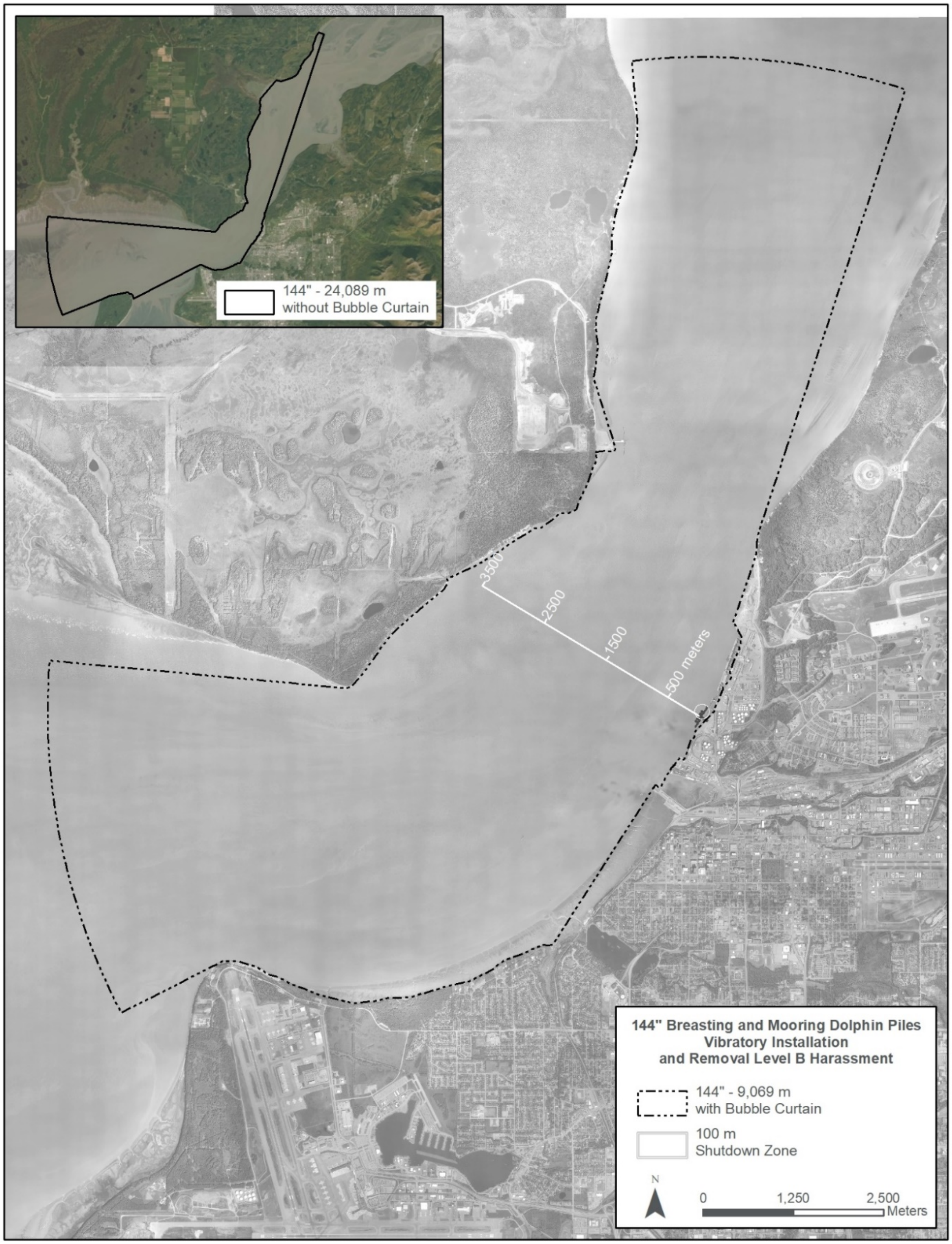

Figure A-6. Level B Harassment Isopleths during Vibratory Installation and Removal of 144- inch Breasting and Mooring Dolphin Piles in Phase 2

Attachment B

Environmental and Marine Mammal Observation Datasheets

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Marine Mammal Sighting Form - PCT Project

Date: *(DD MMM YY, Example 06 JUN 18)* **Location:** **Take Count, Level A:** **Level B:**
(Specific to sighting, Report immediately to Contractor POC)

Group Letter: **Observer(s):** **Data Collector:**
(1st sighting of the day is Group A, letter is unique by day and not by species)

Time *(military)*		**Species** *(circle)*	**Distance** *(meters, animal to noise source)*		**Number of Animals**		**Number of Animals in Each Class**			
Initial Sighting Time		Beluga Whale	Initial Distance		Min Count		*Color classification for belugas only:*			
							White		Dark Gray Calf	
Final Sighting Time		Harbor Seal	Closest Distance		Max Count		Gray		Dark Gray Neonate	
Entered H-Zone B: Y or N										
Time Entered H-Zone B		Harbor Porpoise	Final Distance		Best Count		*Classifications for other species:*		Unknown Color	
Time Exited H-Zone B		Steller Sea Lion	**Initial Heading** *(circle)*		**Number of Animals Entered H-Zone**		Male			
			N NE NW W S SE SW E							
Entered H-Zone A: Y or N		Killer Whale			H-Zone B		Female		Unknown Sex	
Time Entered H-Zone A		other:	**Final Heading** *(circle)*				Adults		Calves/ Pups	
Time Exited H-Zone A		__________	N NE NW W S SE SW E		H-Zone A		Juveniles		Unkn. Age	

Behavior of Marine Mammal(s) *place a 1 next to primary, 2 next to secondary activity (etc.), indicate all behaviors observed:*
___(AP) Avoiding Predation ___(BU) Bubbling ___(CS) Calving ___(D) Diving ___(FO) Feeding Observed
___(FS) Feeding Suspected ___(MS) Mating Suspected ___(M) Milling ___(R) Resting ___(SS) Side-scanning
___(SN) Snorkeling ___(S) Socializing ___(SH) Spyhopping ___(ST) Startled ___(TS) Tail Slapping
___(TW) Tail waving ___(T) Traveling ___(V) Vocalizing ___(O) Other, describe under additional information ___(U) Unknown

Sighting & Behavior Timeline*: **Initial Sighting cue:** ______________________________

Time	*Theodolite Reading*	*Behavior Code*	*Brief Notes* *(additional space below)*	*Time*	*Theodolite Reading*	*Behavior Code*	*Brief Notes* *(additional space below)*
	Y or N				Y or N		
	Y or N				Y or N		
	Y or N				Y or N		
	Y or N				Y or N		
	Y or N				Y or N		

**ALL behavioral changes caused by Project activities or other activities MUST be described under additional information.*

Initial Formation: **Final Formation:** **Spread** (average):

Project Activities

In-Water Work was occurring at initial sighting time? Y or N

In-Water Project Activities (circle): No in-water soft-start shutdown impact pile driving vibratory pile driving

Attenuation Methods (*circle*): None bubble curtains **NO SHUT DOWN**, EXPLANATION REQUIRED:

SHUT DOWN or DELAYED from ________ to ________ (time)

Additional Information (if applicable include more detailed information on behaviors or other information):

Draw locations on hardcopy maps

QC Reviewer____________________QC Date____________

Daily Environmental Conditions Log - PCT

(Recorded every 30 minutes or as conditions change)

Date:____________________ Observer(s):_____________________________ Location: ________________________

(DD MMM YY, Example 06 JUN 18)

Time (hh:mm)	Overall Conditions (Scale 1-10; 1 Poor, 5 Mod., 10 Exc.)	Weather Conditions	Light Conditions (1 Light, 2 Twilight, 3 Dark)	Air Temperature (°C)	Wind Speed (knots)	Wind Direction	Sea State	Cloud Cover (%)	Visibility (km)	Glare (%)	Ice Coverage (%)	Type of Ice	Other Activity (Number, type, and general location of vessels or other sources of in-water disturbance)	Comments

Weather Conditions: (S) Sunny, (PC) Partly Cloudy, (L) Light Rain, (R) Steady Rain, (F) Fog, (OC) Overcast, (LS) Light Snow, (SN) Snow

Sea State: (0) Mirror like, calm; (1) ripples (up to 4 in) without foam crests; (2) small wavelets (up to 8 in); (3) large wavelets (up to 2 ft), perhaps scattered white horses; (4) small waves (up to 3 ft), fairly frequent white horses; (5) moderate waves (up to 6 ft); (6) large waves (up to 9 ft)

Type of ice: (N) New, (B) Brash, (PA) Pancake, (SF) Small Floes, (MF) Medium Floes, (LF) Large Floes, (BT) Belts, (S) Strips, (PI) Pack Ice, (NI) No Ice Present

Daily Project Activities and Communication Log - PCT

Date: ____________ Monitoring Start Time:_____ End Time: _____ Observer(s):_________________________ Location:___________

(DD MMM YY, Example 06 JUN 18) *(military time)*

In-Water Project Activities				
Start Time (hh:mm)	Stop Time (hh:mm)	Type of Project Activity	Attenuation Method	Comments (explain the reason for all shut downs)

Communication				
Time of Communication	MMO (Initials)	Cons. Crew Member	Type of Comm.	Information Communicated

Type of Project Activities: No in-water, soft-start, shutdown, impact pile installation, vibratory pile installation, vibratory pile removal
Attenuation Method: None, air bubble curtains (type), in the dry (dewatered installation or removal)
Type of Communication: Shutdown Notification, Start Up Authorization, General Communication

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Appendix B

Draft Acoustic Monitoring Plan

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DRAFT REPORT

Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Draft Acoustic Monitoring Plan

Prepared for

Port of Alaska

2000 Anchorage Port Road
Anchorage, Alaska 99501

October 15, 2019

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Contents

Tables

Figures

Acronyms and Abbreviations

dB	decibel(s)
HF	high frequency
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
LF	low frequency
µPa	microPascals
MF	medium frequency
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
OW	otariid in water
Pa	Pascals
PAMP	Port of Alaska Modernization Program
PCT	Petroleum and Cement Terminal
POA	Port of Alaska
PTS	permanent threshold shift
PW	phocid in water
QA/QC	Quality Control and Quality Assurance
rms	root mean square
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TL	Transmission Loss
TPP	Test Pile Program

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1 Introduction and Purpose

The Port of Alaska (POA) is modernizing its facilities through the Port of Alaska Modernization Program (PAMP). Located within the Municipality of Anchorage on Knik Arm in upper Cook Inlet, the existing infrastructure and support facilities were constructed largely in the 1960s. They are substantially past their design life, have degraded to levels of marginal safety, and are in many cases functionally obsolete, especially in regard to seismic design criteria and condition. The PAMP will include construction of new pile-supported wharves and trestles, with a planned design life of 75 years.

The Petroleum and Cement Terminal (PCT) Project, a component of the PAMP, is a new construction project intended to replace the existing Petroleum Oil Lubricants Terminal (POL 1) with a new structure that exceeds current seismic standards. The project will occur over two construction seasons, or two phases. The POA is planning to complete Phase 1 construction of the PCT Project between approximately 01 April 2020 and 30 November 2020. In consideration of potential project delays, however, a Marine Mammal Protection Act (MMPA) Incidental Harassment Authorization (IHA) was requested from the National Marine Fisheries Service (NMFS) for the 1-year period from 01 April 2020 to 31 March 2021 for Phase 1. A second construction season for Phase 2 will occur from approximately 01 April 2021 to 31 March 2022.

The PCT will be a new pile-supported structure located along the southern shoreline of the POA (Figure 1-1). The PCT Project will involve construction of the terminal platform, access trestle, and mooring and breasting dolphins; and installation of utility (electricity, water, and communication), petroleum, and cement lines linking the terminal and shore (Figure 1-2). The current PCT design includes both an access trestle (bridge-like structure allowing access to the loading platform) and a temporary construction work trestle. Following construction of the access trestle, the temporary construction work trestle piles will be removed.

This document provides the framework for the Draft Acoustic Monitoring Plan (Monitoring Plan) to be implemented during the PCT Project. The criteria presented here will be used by the hydroacoustic monitoring team to develop the detailed means and methods that will be employed during the Monitoring Plan. Data collection and analysis methods for the Monitoring Plan will be consistent with NMFS guidance on hydroacoustic monitoring for near-source measurements.

In this document, units of measure reported for construction activities are U.S. customary units, which are typically used in construction. Units of measure for scientific information, including acoustics, are metric. When appropriate, units are reported as both U.S. customary and metric. Sound levels are described in decibels (dB), referenced to 1 microPascal (re 1µPa) for peak and root-mean-square (rms) Sound Pressure Levels (SPLs) and re 1µPa^2-sec for Sound Exposure Levels (SELs).

1.1 PCT Project Location and Physical Environment

Cook Inlet is a large tidal estuary that exchanges waters at its mouth with the Gulf of Alaska. Freshwater input to Cook Inlet comes from snowmelt and rivers, many of which are glacially fed and carry high sediment loads. The POA is located in the lower reaches of Knik Arm, in upper Cook Inlet, along the industrial waterfront of Anchorage, just south of Cairn Point and north of Ship Creek (Figure 1-1; Latitude 61° 15′ N, Longitude 149° 52′ W; Seward Meridian). Knik Arm and Turnagain Arm are the two branches of upper Cook Inlet, and Anchorage is located where the two branches join.

Knik Arm extends about 48 kilometers (30 miles) in a north-northeasterly direction to the mouths of the Matanuska and Knik rivers. At Cairn Point, just northeast of the POA, Knik Arm narrows to about 2.4 kilometers (1.5 miles) before widening to as much as 8 kilometers (5 miles) at the tidal flats northwest of Eagle Bay at the mouth of Eagle River. The perpendicular distance to the west bank directly across Knik

Arm from the POA is approximately 4.2 kilometers (2.6 miles). The distance from the POA (east side) to nearby Port MacKenzie (west side) is approximately 4.9 kilometers (3 miles).

Knik Arm comprises narrow channels flanked by large tidal flats that consist of fine, silt-sized glacial flour, sand, mud, and gravel. Approximately 60 percent of Knik Arm is exposed at Mean Lower Low Water. Surface waters in Knik Arm typically carry high silt and sediment loads, particularly during summer, making it an extremely silty, turbid waterbody with low visibility throughout the water column. The Matanuska and Knik rivers contribute the majority of fresh water and suspended sediment into the Knik Arm during summer. Smaller rivers and creeks also enter along the sides of Knik Arm (summary from USDOT and POA 2008).

Tides in Cook Inlet are semi-diurnal, with two unequal high and low tides per tidal day (tidal day = 24 hours, 50 minutes). Due to Knik Arm's predominantly shallow depths and narrow widths, tides near Anchorage are greater than those in the main body of Cook Inlet. The tides at the POA have a mean range of 7.99 meters (26.2 feet), and the maximum water level has been measured at more than 12.5 meters (41 feet) at the Anchorage station (NOAA 2015). Maximum current speeds in Knik Arm, observed during spring ebb tide, exceed 7 knots (12 feet per second). These tides result in strong currents in alternating directions through Knik Arm and a well-mixed water column. The navigation harbor at the POA is a dredged basin in the natural tidal flat. Natural sedimentation processes act to continuously infill the dredged basin throughout the year.

The POA is an active industrial port that is traversed by barges, tug boats, military vessels, and commercial vessels, including container ships, cruise ships, and tenders. The POA's shipping lanes and berths are subject to dredging in order to support port operations. These ongoing uses and activities contribute to elevated background levels of noise in and near the POA. In addition, upper Cook Inlet has some of the highest tides in the world (NOAA 2015), which create strong bidirectional currents and contribute to high ambient underwater sound levels. A number of hydroacoustic studies have measured ambient (background) noise levels in and near the POA that are variable and high (Blackwell 2005; URS 2007; SFS 2009; HDR 2011; Austin et al. 2016).

1.2 PCT Project Description

1.2.1 Permanent Construction

The PCT terminal platform will be supported by approximately 45 round, 48-inch-diameter steel pipe piles and will have a surface area of 15,300 square feet. The platform will connect to the shore by the access trestle, which will be supported by 26 round, 48-inch-diameter steel pipe piles and have a surface area of 11,254 square feet. Six mooring dolphins and three breasting dolphins will each consist of a single round, 144-inch-diameter steel pipe pile. The mooring dolphins will be constructed parallel to and landward of the loading platform face, and the breasting dolphins will be constructed parallel with the PCT loading platform face (Figure 1-2). Catwalks will be installed above the water to connect the dolphins and loading platform. The access trestle is comprised of eight bents (clusters) of three piles each and one bent of two piles at the abutment (Figure 1-2).

An APE D180 diesel impact hammer or equivalent will likely be used to install the 48-inch piles. A Menck 800S hydraulic impact hammer or equivalent will likely be used to install the 144-inch monopile dolphins. An APE 600 or similar vibratory hammer may be used, if necessary, on approximately 10 percent (estimate) of the 48- and 144-inch piles for safety reasons or if a pile encounters an obstruction, and extraction or adjustment is required. It is anticipated that multiple hammers, both vibratory and impact, will be present at the construction site and available for use. On some days, use of two hammers could occur: two vibratory hammers, two impact hammers, or one of each. Use of two hammers within 1 day will increase the production rate on those days, thereby reducing the number of days of work required to complete the project and reducing the overall duration of project construction. Vibratory hammer methods may be used to install loading platform and trestle piles if necessary for safety reasons or if a pile encounters an obstruction.

1.2.2 Temporary Construction

A temporary construction work trestle is anticipated to be necessary to support construction of the access trestle during Phase 1 and will be located adjacent, parallel to and north of the access trestle (Figure 1-3). A driving template inclusive of temporary piles will be required for construction of each of the nine bents of the access trestle. This template will also be used for a welding platform during splicing operations. Temporary construction piles will be needed during Phase 2 to anchor the template that will guide the installation of 144-inch piles at each of the nine dolphin locations (Figure 1-4). Temporary piles are required to be installed using a vibratory hammer due to specific construction and accuracy requirements, sequencing, and schedule.

See Section 1 of the *Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Application for a Marine Mammal Protection Act Incidental Harassment Authorization* for a detailed description of the PCT Project (POA 2019).

Figure 1-1. Location of the PCT Project in Knik Arm

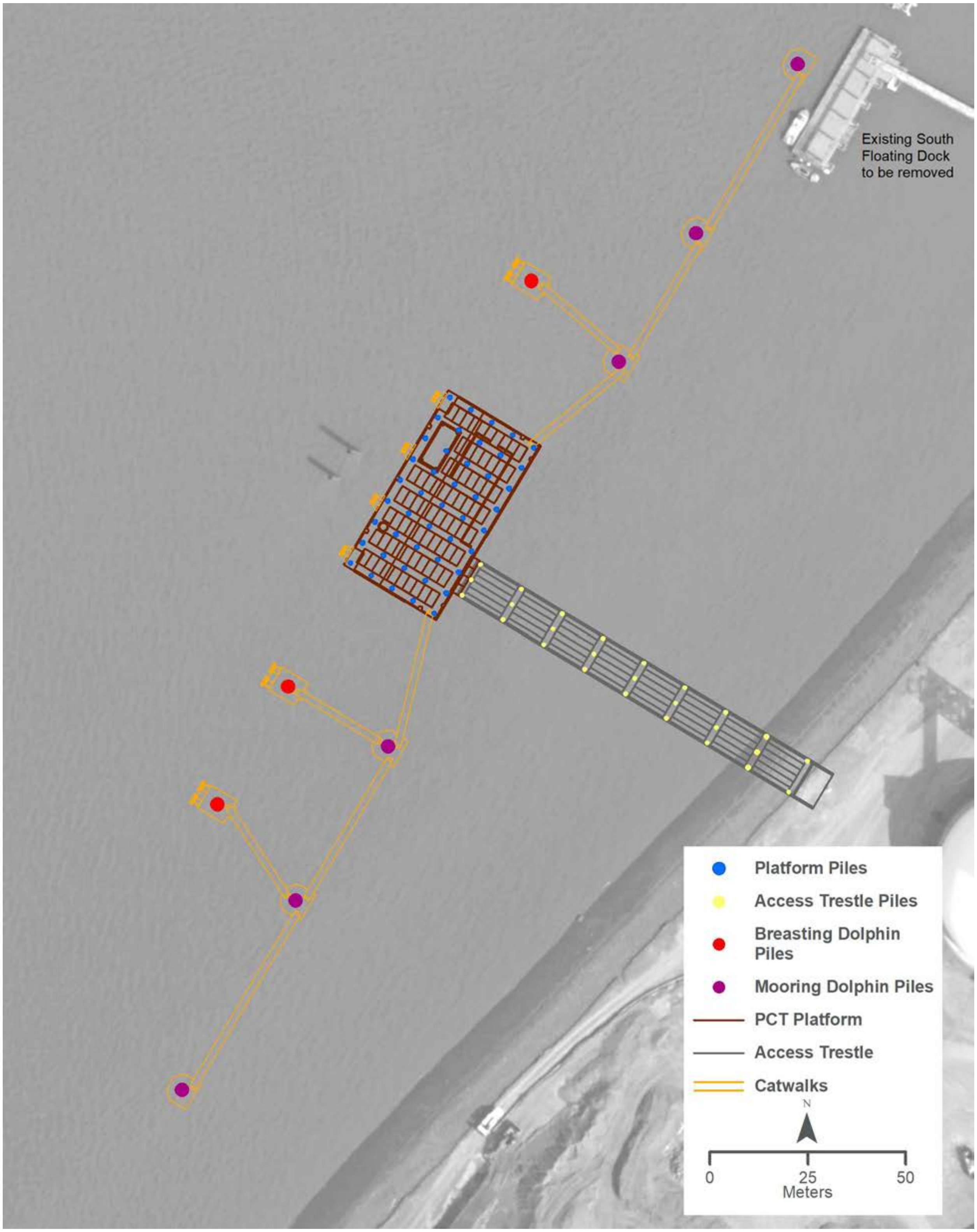

Figure 1-2. Project Footprint and Pile Locations for the Proposed PCT

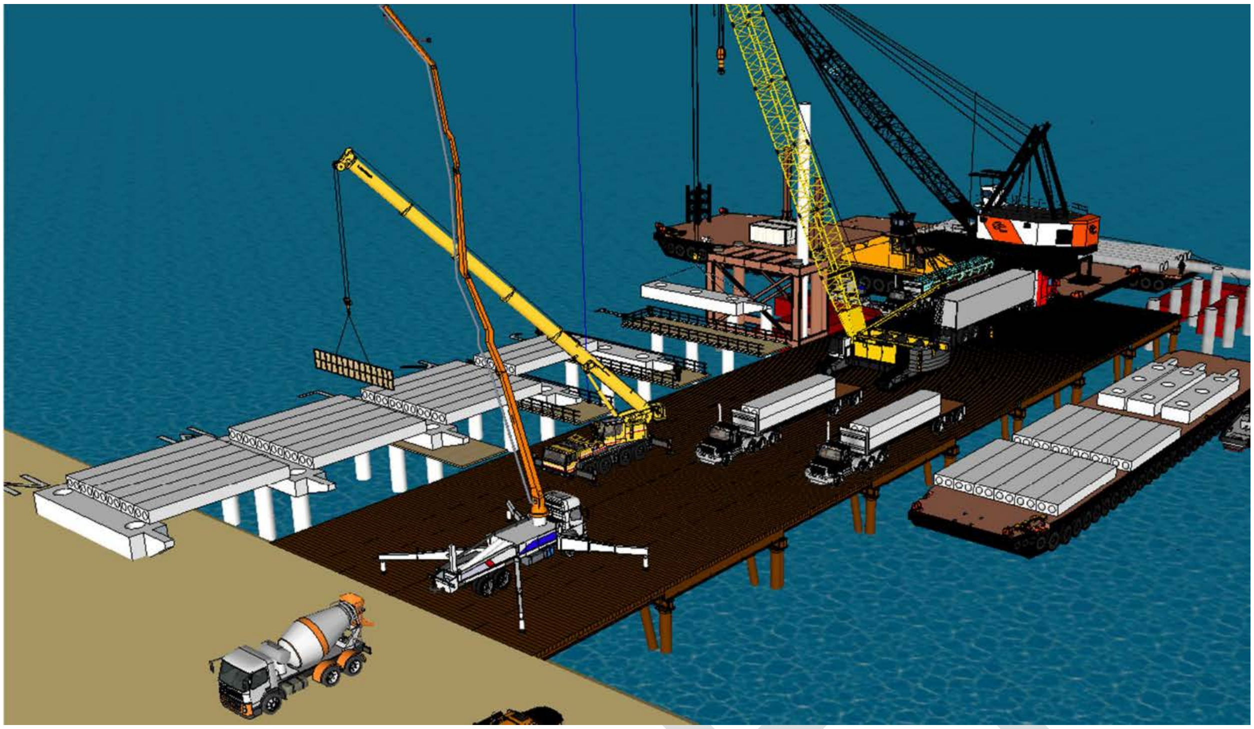

Figure 1-3. Stylized Illustration of a Typical Temporary Construction Work Trestle

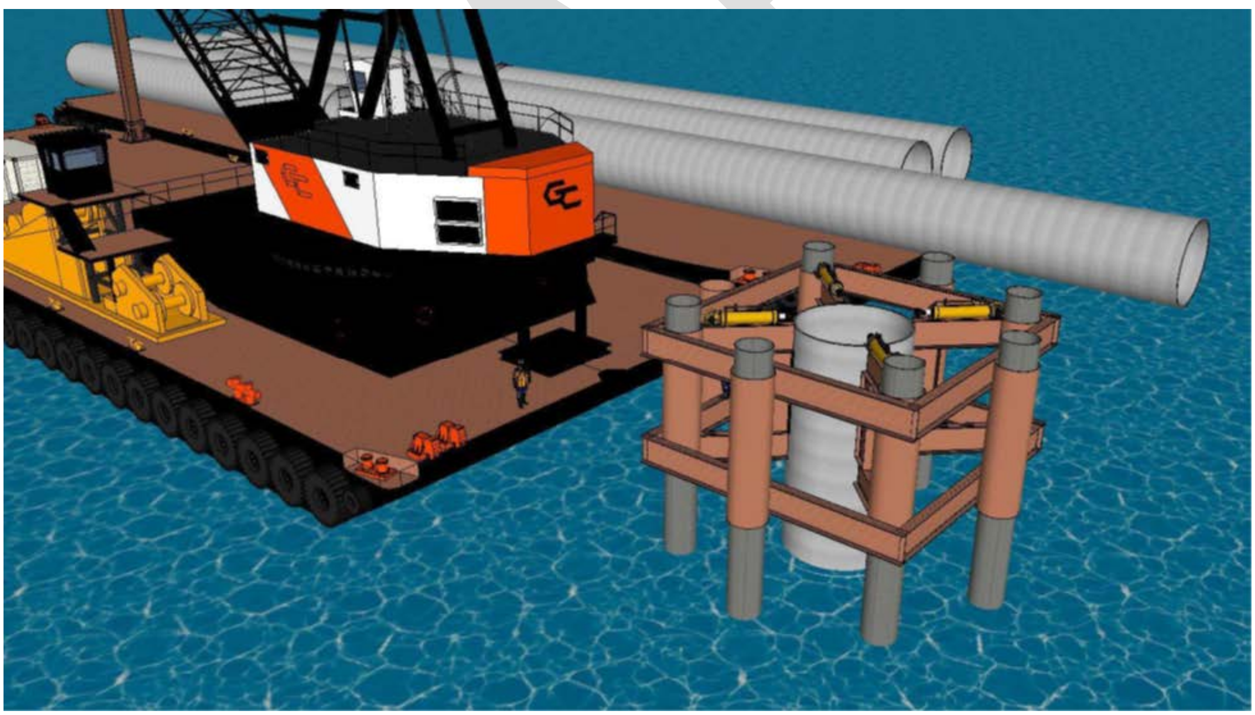

Figure 1-4. Stylized Illustration of a Typical Dolphin Pile Template

1.3 Noise Mitigation: Air Bubble Curtain

The use of an air bubble curtain system as a noise mitigation method is planned for the PCT. A confined air bubble curtain system (bubble curtain) was tested during the 2016 Test Pile Program (TPP) and was found to be an effective method of reducing in-water SPLs from impact and vibratory installation of 48-inch vertical steel pipe piles (see Section 6.3.2 in the *Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Application for a Marine Mammal Protection Act Incidental Harassment Authorization* [POA 2019]).

The TPP used a telescoping steel casing to create an isolation area surrounding the pile through which the air bubbles rose and remained separated from the water column and associated currents. The air was released through a series of vertically distributed bubble rings that were welded to the inside of the steel casing. A compressor provided a continuous supply of air, which was distributed among the layered bubble rings. Air was released from small holes in the bubble rings to create a curtain of air bubbles surrounding the pile, while the steel casing maintained contact with the sea floor. The curtain of air bubbles floating to the surface was effective in inhibiting the transmission of pile installation sounds into the surrounding water column.

The details of the bubble curtain design used for the PCT will be developed by the construction contractor, based on factors such as water depth, current velocities, and pile size; it is anticipated that the new bubble curtain design will be modified from that used for the TPP. For design specifications, see Section 11 of the IHA application (POA 2019).

The bubble curtain will be used during PCT construction for impact and vibratory hammer pile installation on all temporary and permanent vertical piles. A bubble curtain will not be deployed during installation and removal of battered (installed at an angle, not vertical) piles for the temporary construction work trestle due to the difficult geometric application. The effectiveness of a bubble curtain on battered piles is limited because the angle of the battered pile prevents the bubbles from being distributed evenly around the pile surface.

1.4 Hearing Abilities of Marine Mammals

The marine mammals most likely to be observed within the upper Cook Inlet project area include harbor seals (*Phoca vitulina*), beluga whales (*Delphinapterus leucas*), and harbor porpoises (*Phocoena phocoena*; NMFS 2003). Species that may be encountered infrequently or rarely within the project area include killer whales (*Orcinus orca*), humpback whales (*Megaptera novaeangliae*), and Steller sea lions (*Eumetopias jubatus*). These five species form the basis for the design of the Monitoring Plan data collection strategy. Marine mammals that occur in Cook Inlet but are not expected to be observed in the project area include the gray whale (*Eschrichtius robustus*), minke whale (*Balaenoptera acutorostrata*), and Dall's porpoise (*Phocoenoides dalli*).

Hearing is a critical sense for marine mammals. They rely on sound to acoustically sense their surroundings, communicate, locate food, and protect themselves under water. To appropriately assess potential effects from pile installation, it is necessary to understand the frequency ranges that marine mammals are able to hear. NMFS recently published and is currently using updated Technical Guidance (NMFS 2018) to assess the effects of exposure to underwater anthropogenic sound on the hearing of marine mammals.

The Technical Guidance identifies the received levels, or thresholds, above which individual marine mammals are predicted to experience permanent changes (e.g., a permanent threshold shift [PTS]) in their hearing sensitivity from incidental exposure to underwater anthropogenic sound sources (NMFS 2018). NMFS considers the Technical Guidance to represent the best available scientific information and, on this basis, requires that these thresholds and weighting functions be used to assess the potential for auditory injury of marine mammals, which equates to Level A harassment under the MMPA. The models used to derive the PTS onset acoustic thresholds incorporate marine mammal auditory weighting functions in recognition of the variability in hearing sensitivity found among marine mammal species. The auditory weighting functions are defined for five functional hearing groups: low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, and high-frequency (HF) cetaceans; and otariid in water (OW) and phocid in water (PW) pinnipeds (Table 1-1).

Table 1-1. Generalized Hearing Ranges for Functional Marine Mammal Hearing Groups and Port of Alaska Species

Functional Hearing Group	Functional Hearing Range	Marine Mammals in Project Area
Low-frequency (LF) cetaceans	7 Hz to 25 kHz	Humpback whale
Mid-frequency (MF) cetaceans	150 Hz to 160 kHz	Beluga whale, killer whale
High-frequency (HF) cetaceans	275 Hz to 160 kHz	Harbor porpoise
Phocid in water (PW) pinnipeds	50 Hz to 86 kHz	Harbor seal
Otariid in water (OW) pinnipeds	60 Hz to 39 kHz	Steller sea lion

Notes: Hz = Hertz; kHz = kilohertz

Source: NMFS 2018

NMFS guidance recommends that 20 kilohertz (kHz) be used as the high-frequency limit for all pile-driving assessments of Sound Source Levels (see Appendix A). NMFS recommends that the low-frequency limit is defined by the estimated auditory bandwidth for each functional hearing group (Table 1-1; see Appendix A). For the PCT, the low-frequency limit is determined by the presence of humpback whales. It is generally difficult to measure below about 10 Hertz (Hz). The range of interest, and the range that will be monitored, will therefore be 20 Hz to 20 kHz.

1.5 Underwater Sound Thresholds for Marine Mammals

NMFS uses sound exposure thresholds to determine when an activity that produces sound may result in impacts to a marine mammal such that a take by harassment could occur. The IHA for the PCT uses the Technical Guidance for assessing Level A harassment levels and the NMFS interim guidance for assessing Level B harassment levels. NMFS has developed a summary of PTS onset acoustic thresholds for assessing Level A harassment, and acoustic criteria for assessing Level B harassment, of marine mammals from exposure to noise from impulsive and non-impulsive underwater sound sources (Table 1-2).

The POA proposes to implement a marine mammal monitoring and mitigation strategy that will avoid or minimize impacts to marine mammals to the greatest extent practicable. The Monitoring Plan includes two general components: acoustic measurements and visual observations of marine mammals. Visual marine mammal monitoring is discussed in more detail in the *Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Application for a Marine Mammal Protection Act Incidental Harassment Authorization* (POA 2019).

Table 1-2. Summary of PTS Onset Acoustic Thresholds for Assessing Level A Harassment, and Acoustic Criteria for Assessing Level B Harassment, of Marine Mammals from Exposure to Noise from Impulsive (Pulsed) and Non-impulsive Underwater Sound Sources

Species Group	**PTS Onset Acoustic Thresholds (Received Level)**		
	Hearing Group	**Impulsive**	**Non-impulsive (Continuous)**
Level A Harassment			
Cetaceans	LF	$L_{pk,flat}$ 219 dB $L_{E, LF, 24h}$ 183 dB	$L_{E, LF, 24h}$: 199 dB
	MF	$L_{pk,flat}$ 230 dB $L_{E, MF, 24h}$ 185 dB	$L_{E, MF, 24h}$: 198 dB
	HF	$L_{pk,flat}$ 202 dB $L_{E, HF, 24h}$ 155 dB	$L_{E, HF, 24h}$: 173 dB
Pinnipeds	PW	$L_{pk,flat}$ 218 dB $L_{E, PW, 24h}$ 185 dB	$L_{E, PW, 24h}$: 201 dB
	OW	$L_{pk,flat}$ 232 dB $L_{E, OW, 24h}$ 203 dB	$L_{E, OW, 24h}$: 219 dB
Level B Harassment			
Cetaceans	LF MF HF	160 dB rms	120 dB rms
Pinnipeds	PW OW	160 dB rms	120 dB rms

Note: $L_{pk,flat}$ = peak sound pressure level (unweighted); $L_{E,24h}$ = sound exposure level, cumulative 24 hours

Source: NMFS 2018

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2 Test Pile Program Hydroacoustic Monitoring Results

Hydroacoustic monitoring for the TPP carried out in May and June 2016 (Austin et al. 2016) included hydroacoustic measurements for 10 test piles. Autonomous sound recorders were deployed at nominal distances of approximately 33 to 56 feet (10 to 17 meters) and about 3,000 to 3,600 feet (about 1 kilometer) from each pile during installation, and a mobile hydrophone system was drifted during measurements to target data collection at ranges corresponding to marine mammal disturbance thresholds. Ambient sound recordings were also measured at two locations during a 3-day break in pile installation activities. Details of this monitoring program can be found in Austin et al. (2016) and results are summarized in the *Anchorage Port Modernization Program Test Pile Program Report of Findings* (POA 2016).

2.1 Measured Ambient Sound Levels

Ambient noise levels during the 2016 TPP were measured in two locations, one within the POA and one about 1,000 meters offshore of the POA, during a 3-day break in pile installation (Austin et al. 2016). The median values of the background SPLs from continuous 60-second sample averages ranged from 117.0 dB within the POA to 122.2 dB offshore (Table 2-1). In addition to the unweighted levels, the frequency weighted levels for LF cetaceans, MF cetaceans, HF cetaceans, and PW pinnipeds were also calculated (see Table 2-1). Weighted LF cetacean levels are virtually the same as the unweighted levels. For the other weightings, the levels are lower than the unweighted levels by 3.1 to 7.6 dB. During the measurements, some typical activities and sound levels were noted, such as noise from current flow at the nearshore location and the passage of vessels at the offshore location. Throughout the data set, the offshore levels were consistently higher than the nearshore levels by 3.4 to 5.3 dB. Although different noise metrics were reported (L_n and mean levels), the median levels are thought to be the most appropriate characterization of the nominal ambient conditions. Based on these measurements, an ambient noise level of 122.2 dB is anticipated during PCT construction (POA 2016). A diurnal pattern to the ambient sound data was not apparent.

Table 2-1. Ambient Noise Levels

Location	SPL (dB re 1µPa)	
	Unweighted Median	**Unweighted Mean**
Ambient – Dock	117	138.8
Ambient – Offshore	122.2	136

Source: Austin et al. 2016

Notes: SPL = Sound Pressure Level; dB re 1µPa = decibels referenced to 1 microPascal

2.2 Measurements of Impact Pile Installation – 48-inch-diameter Piles

Monitoring Plan measurements for installation of unattenuated 48-inch-diameter piles were collected during the TPP. Acoustic data from the TPP were summarized for unattenuated impact pile installation Table 2-2 based on continuous measurements performed near the source and at about 1 kilometer from the pile, and were reported as median sound levels (POA 2016). The distances from the piles varied slightly from pile to pile; however, the positions are referred to generically as 10 meters (near 10-m) and 1,000 meters (near 1,000-m; Table 2-2). Peak SPL, rms, Sound Exposure Level (SEL), and transmission loss (TL) coefficients were calculated for each unattenuated pile (Austin et al. 2016; Table 2-2).

Table 2-2. Summary of Unweighted Sound Levels for Unattenuated Impact Pile Installation for the TPP

Condition	Test Pile Program Pile		
	IP1	**IP5**	**IP6[a]**
Hammer Type[b]	H	D	D
Distance (m)	14	11	12
Peak, dB near 10-m Median UNWEIGHTED	213.2	212.5	208.7
rms, dB near 10-m UNWEIGHTED	199	197.9	193.2
SEL, dB near 10-m UNWEIGHTED	185.1	186.7	184.5
Distance (m)	959	968	977
Peak, dB near 1,000-m Median UNWEIGHTED	176.7	176	172.4
Peak, dB near 1,000-m 90th% UNWEIGHTED	178.2	178.6	173.8
rms, dB near 1,000-m UNWEIGHTED	163.1	166.5	158.4
SEL, dB near 1,000-m UNWEIGHTED	152.4	155.8	150.7
Distance (m)	10	10	10
Peak, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	215.4	213.1	209.9
rms, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	201.2	198.5	194.4
SEL, dB computed to 10-m Median (standardized) UNWEIGHTED[c]	187.7	187.4	185.7

[a] Air bubble curtain turned on and off, but curtain structure remained in place and may have affected sound propagation. Therefore, this pile was not used to assess sound levels, as indicated by grayed text.

[b] H= hydraulic; D = diesel

Source: Austin et al. 2016

Notes: dB = decibels; m = meters; rms = root mean square; SEL = Sound Exposure Level.

Sound levels for piles IP1, IP5, and IP6 are the average reported single-strike levels associated with each pile and do not take into account differences in the numbers of strikes used to install each pile. The data indicate that sound levels were comparable for piles IP1 and IP5 (Table 2-2). Levels were lower at both the near source and far field positions for the unattenuated driving of IP6. The lower levels may have been an effect of the confined air bubble curtain fixture. As a result, sound levels for the unattenuated installation of pile IP6 were not used in this assessment (Table 2-2). Given the small sample size and low variability in levels between the two completely unattenuated conditions (IP1 and IP5), the reported levels for the two piles were averaged to compute the near-source level and TL coefficient. Data did not indicate that one pile performed differently from the other or that data from one pile would be preferable to data from the other. The two piles were weighted equally when averaged (Table 2-2).

Numerical criteria presented in the NMFS Technical Guidance (NMFS 2018) consist of both an acoustic SEL_{cum} threshold and an auditory weighting function. NMFS applies specific marine mammal auditory weighting functions for defining the onset of PTS for the five hearing groups: LF cetaceans, MF cetaceans, HF cetaceans, PW pinnipeds, and OW pinnipeds. Austin et al. (2016) analyzed the measured sound levels at both the near 10-m and near 1,000-m positions by applying the auditory weighting functions. Austin et al. (2016) also provided the one-third-octave band median sound levels for the measurements of impact pile installation, which were used to calculate the SEL values for MF and HF cetaceans for the near-10 m position (Table 2-3) for IP1. These were single-strike SEL levels for both the near 10-m and the near 1,000-m positions (Table 2-3). TL coefficients were computed for these data, since they vary by hearing group.

Table 2-3. Median SEL Single-Strike Sound Levels and TL Coefficients for the TPP

Condition	Test Pile Program Pile		
	IP1	IP5	Average
Hammer Type[a]	H	D	
Distance (m)	14	11	
SEL, dB near 10-m LF cetaceans	183.6	184.4	
SEL, dB near 10-m MF cetaceans	164.1[b]	165.3	
SEL, dB near 10-m HF cetaceans	161.2[b]	162.9	
SEL, dB near 10-m PW pinnipeds	176.3	173.7	
SEL, dB near 10-m OW pinnipeds	176.6	172.6	
Distance (m)	959	968	
SEL, dB near 1,000-m LF cetaceans	150.1	152.4	
SEL, dB near 1,000-m MF cetaceans	118.3	123.4	
SEL, dB near 1,000-m HF cetaceans	110.5	118.5	
SEL, dB near 1,000-m PW pinnipeds	141.1	141.0	
SEL, dB near 1,000-m OW pinnipeds	141.3	140.1	
TL Coefficient UNWEIGHTED	17.8	15.9	16.85
Distance (m)	10	10	10
SEL, dB computed to 10-m LF cetaceans[c]	185.0	185.0	185.0
SEL, dB computed to 10-m MF cetaceans[c]	164.1	164.1	164.1
SEL, dB computed to 10-m HF cetaceans[c]	160.2	160.2	160.2
SEL, dB computed to 10-m PW pinnipeds[c]	176.1	176.1	176.1
SEL, dB computed to 10-m OW pinnipeds[c]	176.3	176.3	176.3

[a] H= hydraulic; D = diesel

[b] Recomputed by Illingworth & Rodkin, Inc., using the unweighted one-third-octave band median sound levels.

[c] Computed using the near 10-m levels and associated TL coefficient by Illingworth & Rodkin, Inc.

Notes: dB = decibels; HF = high frequency; LF = low frequency; m = meters; MF = mid-frequency; OW = otariid in water; PW = phocid in water; SEL = Sound Exposure Level; TL = transmission loss.

NMFS does not apply auditory weighting functions to assess behavior or Level B harassment. Unweighted levels at near 10 meters and their TL coefficients, reported by Austin et al. (2016), were used in this assessment for the measured unattenuated impact pile installation conditions (Table 2-4).

Table 2-4. Root Mean Square Single-Strike Sound Levels and TL Coefficients for 48-inch Piles for the 2016 TPP

Condition		Test Pile Program Pile		
		IP1	IP5	Average
	Hammer Type[a]	H	D	
	Distance (m)	14	11	
rms, dB near 10-m UNWEIGHTED		199.0	197.9	
	Distance (m)	959	968	
rms, dB at 1,000-m UNWEIGHTED		163.1	166.5	
	Distance (m)	10	10	10
rms, dB computed at 10-m UNWEIGHTED[b]		201.2	198.5	199.9
TL Coefficient UNWEIGHTED		19.2	17.5	18.35

[a] H= hydraulic; D = diesel

[b] Computed using the near 10-m levels and associated TL coefficient by Illingworth & Rodkin, Inc.

Note: dB = decibels; rms = root mean square; m = meters; TL = transmission loss.

2.3 Anticipated Acoustic Noise Levels

For a detailed description of how sound levels for the different pile sizes and installation methods were estimated, see the PCT IHA application (POA 2019). Estimates are summarized in Table 2-5.

Table 2-5. Estimates of Unweighted Underwater Sound Levels Generated during Vibratory and Impact Pile Installation and Vibratory Pile Removal, Standardized to 10 Meters

Method and Pile Type	Unweighted Sound Level at 10 Meters						Data Source for Unattenuated SSL
	Without Bubble Curtain			With Bubble Curtain			
Phase 1							
Vibratory Hammer	**dB rms**			**7 dB Reduction, dB rms**			
48-inch steel	168			161			POA Report of Findings 2016a
36-inch steel	166			159			U.S. Navy 2015
24-inch steel	161			154			U.S. Navy 2015
Impact Hammer	**dB rms**	**dB SEL**	**dB peak**	**7 dB Reduction**			
				dB rms	**dB SEL**	**dB peak**	
48-inch steel	200	187	215	193	180	208	POA Report of Findings 2016a
24-inch steel	193	181	210	186	174	203	U.S. Navy 2015

Method and Pile Type	Unweighted Sound Level at 10 Meters						Data Source for Unattenuated SSL
	Without Bubble Curtain			With Bubble Curtain			
Phase 2							
Vibratory Hammer	**dB rms**			**7 dB Reduction, dB rms**			
36-inch steel	166			159			U.S. Navy 2015
Impact Hammer	**dB rms**	**dB SEL**	**dB peak**	**7 dB Reduction**			
				dB rms	**dB SEL**	**dB peak**	
144-inch steel	209	198	220	202	191	213	Caltrans 2015, I&R unpublished data
36-inch steel	194	184	211	187	177	204	U.S. Navy 2015

Notes: dB = decibels; I&R = Illingworth & Rodkin, Inc.; rms = root mean square; SEL = Sound Exposure Level; SSL = Sound Source Level.

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3 PCT Sound Source Verification Study Objectives

Hydroacoustic monitoring for the PCT will take the form of a Monitoring Plan, the primary purpose of which will be to determine the effectiveness of the bubble curtain system and inform the process for obtaining Letters of Authorization under the MMPA during Phase 2 of the PAMP. A secondary purpose will be to determine empirical distances to the Level A injury and Level B disturbance zones for the PCT, which were estimated in the PCT IHA application (POA 2019) based on empirical measurements from the TPP in summer 2016.

Pile installation can cause elevated underwater noise levels, which have the potential to disturb or injure marine mammals. There is concern that the noise levels associated with pile installation for the PCT Project may affect marine mammals that occur within the zone of ensonification. The Monitoring Plan will be performed in compliance with MMPA and Endangered Species Act permitting requirements.

The Monitoring Plan will have the following objectives:

- Phase 1: Measure and record sounds for 24-inch, 36-inch, and 48-inch piles during Phase 1:
    - A sample size of five to ten 24-inch piles, seven 36-inch piles, and five to ten 48-inch piles will be measured. A sample size of one to three piles will be tested with a bubble curtain turned on and off during vibratory installation of 24-inch and 36-inch piles and impact installation of 48-inch piles to measure and quantify the effectiveness of noise reduction with the bubble curtain turned on.
    - Of those 24-inch and 36-inch piles that will be measured, 1 to 2 piles may be measured during proofing using impact installation methods if logistics are able to be worked out (proofing of piles generally is limited to a very short time frame, approximately 5-10 minutes).
- Phase 2: Measure and record sounds for 144-inch piles during Phase 2:
    - Two 144-inch piles driven with an impact hammer will be measured. A sample size of one 144-inch pile installed with an impact hammer will be measured with the bubble curtain turned on and off to measure and quantify the effectiveness of noise reduction with the bubble curtain turned on.
    - If SPLs for the 144-inch piles are highly variable, a third pile may be monitored.
- Analyze data for all piles measured in accordance with NMFS recommendations and best-practices protocol:
    - Compute the SPL for each pile at the measurement site and at 10 meters, and compute the TL coefficient based on measurements near 10 meters, 300 to 1000 meters, and 3 to 4 kilometers.
    - Compute the areas of the PTS onset acoustic thresholds for assessing Level A harassment, and acoustic criteria for assessing Level B harassment based on the computed SSLs and TLs from the measurements of single piles.
    - Compute the effectiveness of the bubble curtain by quantifying underwater sound levels during pile installation with and without a bubble curtain operating for 24-, 36-, 48-, and 144-inch piles and compare data to levels predicted in the IHA.
- Verify that the Level A and Level B harassment zones predicted for the PCT IHA are adequate to protect marine mammals and their hearing, and are adequate for application to future PAMP construction projects. If necessary, make adjustments to the harassment zones.

- Report to NMFS on Monitoring Plan findings.

It is possible that, due to weather, safety, equipment availability, logistics, and other unforeseen constraints, fewer piles will be measured than anticipated and planned. The POA and its contractors will attempt to measure the full set of piles as described here, but this may not be attainable. Results from hydroacoustic monitoring will be available to assist in design decisions for future PAMP construction projects, as well as in developing monitoring and mitigation methods to reduce potential impacts to marine mammals.

4 Monitoring Plan Methodology

Any deviations from this methodology must be pre-approved by the POA before the work takes place.

4.1 Roles and Responsibilities

The hydroacoustic monitoring team coordinator will manage implementation of the Monitoring Plan (data collection, analysis, and reporting) in close coordination with the PCT construction contractor. A single point of contact will be identified by the construction contractor on a daily basis on both the hydroacoustic crew and construction crew to provide the lead authority for that day. The hydroacoustic coordinator and daily hydroacoustic point of contact are responsible for understanding all project-specific hydroacoustic monitoring requirements. The Port Construction Manager/Resident Engineer will provide oversight to all contractors.

4.2 Sound Pressure Levels

The methodology described below is consistent with a 31 January 2012 guidance memorandum issued by NMFS titled *Data Collection Methods to Characterize Impact and Vibratory Pile Driving Source Levels Relevant to Marine Mammals* (Appendix A).

4.2.1 Data Collection

4.2.1.1 Selection of Piles

Before the Monitoring Plan commences, the hydroacoustic coordinator, construction contractor, and Port Construction Manager/Resident Engineer will meet to determine which piles will be included in the Monitoring Plan. Considerations will include:

- Pile location.
- Water depth. Piles in deeper waters are preferred because they better represent typical installation conditions for the PCT and other future project components of the PAMP.
- Ensuring similar conditions between the sample of piles measured with a bubble curtain and the sample of piles measured without a bubble curtain (e.g., comparable water depths, substrate conditions, and hydrophone locations). For this reason, the bubble curtain will be turned on and off to collect comparable samples of sound data that are attenuated and unattenuated by a bubble curtain.
- Access to measurement positions.
- Safety of the hydroacoustic and construction crews.

4.2.1.2 Hydrophone Positions

Monitoring underwater sound in Knik Arm and the active shipping port during construction activity is challenging. Therefore, the positions at which hydrophones would be deployed are subject to change. However, all reasonable attempts will be made to position hydrophones at approximately 10 to 20 meters (33 to 65 feet), 300 to 1,000 meters (1,000 to 3,000 feet), and 3 to 4 kilometers (2 to 3 miles). Each measurement distance will include a single hydrophone placed within an acoustic line of sight to the pile. Near-field hydrophones will be located on a dock, barge, or other structure within the POA. Mid-range hydrophones will be placed at a temporary mid-channel location with the aid of a small vessel deployed from the POA. Where possible, a hydrophone will be located in the lower half of the water column, between 2 meters off the bottom and mid-depth. For example, if the mean water depth during pile installation is anticipated to be 10 meters (33 feet) at the pile, the hydrophone will be positioned at a depth of 5 to 8 meters (17 to 27 feet). The far-field hydrophones may be located at appropriate mooring sites at or near Point MacKenzie, mounted to a dock or pier, or moored offshore, in a location where they will not be damaged by vessels or interfere with other activity. Hydrophones will be placed out of shipping lanes, outside of dredged channels, and will avoid noted irregular bathymetry, such as drastic rises or sills, between the source and hydrophones.

4.2.1.3 Measuring the Bubble Curtain Effectiveness

Sound levels will be measured during installation of piles with and without a bubble curtain to measure the effectiveness in reducing underwater sound pressure levels. In order to test the effectiveness of the bubble curtain, a small number of 24-, 36-, 48-, and 144-inch piles, as feasible, will be tested with the bubble curtain turned on and off. The number of piles to be measured and the specific timing for testing the 48- and 144-inch piles with and without a bubble curtain will be dependent upon conditions and construction timing, and will be coordinated with NMFS to reduce underwater acoustic noise impacts to beluga whales.

Sound levels will be measured with the air bubble curtain operating, then turned off, and then turned back on. Ideally, measurements for each condition would occur over 5 minutes for each condition. However, this may be constrained by driving conditions that require each period to be shorter or longer. For example, pile driving may progress faster than anticipated where the full cycle of 5-minute on/off tests is not possible. On the other hand, levels may take a while to stabilize requiring the 5-minute duration to be extended for at least one of the conditions.

4.2.1.4 Equipment Required

The hydrophone used for SPL data collection must be appropriate for the frequency range of measurements (i.e., 20 Hz to 20 kHz; Section 1.4). A Reson Model TC4013 or TC4033 or equivalent hydrophone with a known and flat frequency response curve across the bandwidth of measurements will be used. The hydrophone will be appropriate for measuring sound across the frequency range. The particular hydrophone sensitivity (with gain stage included) will be noted. A minimum sampling rate of 48,000 Hz will be used during monitoring. Receiving sensitivities must be sufficient to measure high acoustic pressures (Appendix A). The hydrophone and associated electronic recording networks must be capable of measuring peak pressures as high as 220 dB re: 1µPa without distortion. Care must be taken at greater distances to measure levels above instrument background.

4.2.1.5 Sampling Schedule

During Phase 1, two sampling periods may be required for pile installation in order to adequately capture sound levels for all pile sizes during each installation technique. The PCT will be constructed simultaneously from the marine side and the land side. The marine approach will include a marine derrick barge mounted with an impact hammer for installing the 48-inch platform piles. The landside approach will include a crawler crane to construct both the temporary construction work trestle and the permanent trestle. The crawler crane will work from the landside out in a leap-frog or top-down construction technique to advance construction out to the platform. The crawler crane will include accommodations for both a vibratory hammer and an impact hammer to install the temporary 24-inch and 36-inch piles and permanent 48-inch piles as the trestles are advanced out to the platform.

Sound levels for vibratory installation of 24-inch and 36-inch and impact installation of 48-inch piles will be measured. Noise levels during impact proofing of 24-inch or 36-inch piles may be measured (reference discussion above), as logistics allow. Note that 24-inch and 36-inch piles that are part of the temporary trestle will first be installed near shore in mud or very shallow water, which precludes collection of underwater measurements and in some instances deployment of the bubble curtain; successive installations will take place farther offshore. Marine-based installation of 48-inch piles will be going on simultaneously and may provide the opportunity to collect the full range of pile sizes and hammer types during a single sampling period if scheduling of multiple activities can be arranged.

During Phase 2, sound measurements for impact installation of 144-inch piles will occur. Testing of the bubble curtain effectiveness for attenuation of underwater noise for 144-inch piles is described in Section 4.2.1.3. Sound measurements for vibratory installation of 36-inch piles may occur during Phase 2 if adequate monitoring is not able to be obtained during Phase 1.

The construction contractor will keep detailed and accurate notes of start and stop times and ramp-up times, as well as the times that the bubble curtain is turned on and off (see Section 5 for additional hydroacoustic monitoring requirements).

4.2.2 Data Analysis

Sound measurements will be reported in overall peak, SPL (in terms of pulse rms for impact pile driving), and SEL across the entire frequency band for each of the functional hearing groups found in the project area (i.e., 20 Hz to 20 kHz). Each pile installed will be considered a single event (Appendix A). Impact pile sound pulses will be characterized by measuring the rms SPL. This requires integrating sound from each pulse across the portion where 90 percent of the acoustic energy is contained (using the 5^{th}–95^{th} percentiles to establish the time window) and averaging across all waves in the pile-installation event (i.e., as demonstrated in Figure 1 of Madsen et al. 2006). Peak pressure will be the maximum absolute instantaneous pressure in that pulse. The integration of sound pressure over a 1-second period of the pulse would be the SEL.

4.3 Transmission loss

Transmission loss in the POA marine environment during pile installation of 48-inch steel pipe piles was measured during the 2016 TPP (Austin et al. 2016) and summarized in Table 2-4 and the *Port of Alaska Modernization Program Petroleum and Cement Terminal Project: Application for a Marine Mammal Protection Act Incidental Harassment Authorization* (POA 2019).

A regression analysis of sound levels will be used to develop the relationship between distance and sound level for all pile sizes measured. This would be performed for peak pressure, rms SPL, and SEL. The regression provides the statistical relationship of sound level over the range of distances measured. The source level is expressed as the reference sound level (derived as a 1-meter source level) and a transmission loss coefficient expressed as a multiplier of a common Logarithmic function (base 10) of the distance. Note that the sound level is not a true sound level. This is a sound level that best fits the regression relationship of sound and distance.

4.4 Other Sources of Noise

During collection of hydroacoustic data, the start times, end times, and types of unavoidable extraneous noise sources such as vessel traffic and air traffic, if any, will be recorded by the hydroacoustic monitoring team. Measurements collected during time periods with significant levels of additional noise must be removed from the data set before analysis. Of particular concern are dredging operations at the POA and potential pile installation at other locations in Knik Arm. Coordination of schedules may be required to prevent interference from dredging or other construction projects.

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5 Contractor Requirements

5.1 Data Collection

The hydroacoustic monitoring team will collect data both electronically and on data forms. Data forms to be used during the Monitoring Plan will also be submitted by the construction contractor for review by the Port Construction Manager/Resident Engineer at least 2 weeks prior to the start of the PCT in-water construction. Data forms will be scanned, backed up, and submitted for review by the Port Construction Manager/Resident Engineer within 24 hours of each collection time period.

5.1.1 Data Form

At a minimum, the hydroacoustic crew will collect the following data on the data form:

- Date
- Contractor name
- Pile number
- Pile location
- Activity (e.g., vibratory installation, impact installation, removal)
- Bubble curtain (used or not used)
- Water depth at the work site (i.e., at the pile being installed) every 30 minutes during pile installation or removal
- Depth to which each pile was driven
- A general description of the characteristics of the substrate into which each pile was driven

5.1.2 Reporting

Data summaries will be prepared to report the following information:

- For each recorded impact pile-driving event, the following will be reported:
  - The maximum and median values of the peak pressure, defined as the maximum absolute value of the instantaneous pressure (overpressure or under pressure)
  - The median value of the rms sound pressure across 90 percent of the pile strike energy (pulse rms)
  - The median value of the pulse duration used to compute the rms pulse SPL
  - The median value of the SEL, measured for each second or pile strike, and the accumulation of SEL across the duration of the event.
- Time history trace of measured sound levels.
- Mean one-third-octave band spectra and samples of the computed median power spectral density for selected events (in final report)

Following the completion of all monitoring activities, a Monitoring Plan Report will be prepared. The report will describe the sources of the sound, the environment, and the measurements. The methodology employed to make the measurements will be described. Results will be presented as overall sound pressure levels and displays of one-third-octave band sound levels. Specific sounds will be identified.

Preliminary reports are available following measurements events; however, these are based on live measurements and subject to change as analysis of audio recordings provide pulse-specific measurements and the elimination of contamination to the data set (e.g., filtering of very low frequency background noise). The intent is to measure these sounds live and minimize any post-measurement analyses. A preliminary field summary will be available to NMFS within 6 weeks of completion of the field measurements, and a final full report will be available within 90 days.

In addition, audio recordings of pile-driving sounds, which can be measured/analyzed per the requirements of this Monitoring Plan, will be collected and stored in a digital format that can be analyzed using commercially available software (i.e., .wav format).

5.2 Quality Control and Quality Assurance

Hydroacoustic equipment shall be tested within 48 hours prior to acoustic monitoring to ensure that the equipment is fully functional. The hydroacoustic monitoring team shall perform and document a calibration of all applicable equipment prior to initiation of sound monitoring. The hydroacoustic monitoring team will resolve any equipment issues that arise prior to the start of project activities.

5.3 Reporting

Communication is a key element to successful construction of the PCT. The hydroacoustic monitoring team coordinator, construction contractor and Port Construction Manager/Resident Engineer will communicate on a daily basis about the Monitoring Plan.

5.3.1 For Each Measurement Day

Within 2-3 workdays of the completion of pile installation, the hydroacoustic monitoring team coordinator will provide the POA with a preliminary summary report on each individual pile that was measured. This will include peak SPL, median rms levels (pulse or continuous), and cumulative SEL. This report is meant to provide preliminary results in summary format. The pile report form will be provided to the POA for review at least 2 weeks prior to the commencement of the measurement portion of the Monitoring Plan. Due to limited available information for 144-inch piles, once the initial monitoring of the 144-inch piles is complete, a draft data summary will be submitted to NMFS within 1-2 weeks.

5.3.2 Data Processing and Final Report

The hydroacoustic monitoring team is responsible for post-processing of data. The final report will demonstrate the achievement of the Monitoring Plan objectives. The report, at minimum, will include:

- Methodology: field data collection, post-processing, data analysis methods, and QA/QC documentation
- Peak, SPLs, and SELs for each pile monitored for each measurement position
- Frequency spectra of SEL levels and applicable computation of marine mammal weighting frequency adjustments
- Computation of TLs intended to estimate sound levels over distance to assist in the assessment of the marine mammal PTS and Level B harassment isopleths
- Assessment of the bubble curtain's performance compared to bubble curtain on/off conditions and unattenuated pile installation during the TPP

A Microsoft™ Word version of the report will also be provided to facilitate review and editing.

Additionally, the raw data and data summary in one-third-octave band intervals will be provided to the Port Construction Manager/Resident Engineer. This includes high-quality audio recordings, digital data that can be viewed and analyzed using commercially available software, calibration documentation, field notes, measurement positions coordinates (i.e., GPS data), and photo documentation. For each pile, overall SPLs and frequency spectra (minimum one-third-octave band center) data shall be provided for each pile strike. For each pile, the average and median sound levels shall be provided.

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6 Literature Cited

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