Application for a Marine Mammal Protection Act Incidental Harassment Authorization

Prepared for

Port of Anchorage

2000 Anchorage Port Road
Anchorage, Alaska 99501
United States of America

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Prepared by

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Acronyms and Abbreviations

ADF&G	Alaska Department of Fish and Game
ANVSA	Alaska Native Village Statistical Area
APMP	Anchorage Port Modernization Project
ARRC	Alaska Railroad Corporation
BA	Biological Assessment
dB	decibels
dBA	A-weighted decibels
CFR	Code of Federal Regulations
CIMMC	Cook Inlet Marine Mammal Council
CPT	Cone Penetrometer Tests
DOT&PF	Alaska Department of Transportation and Public Facilities
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FR	*Federal Register*
GPS	Global Positioning System
Hz	Hertz
ICRC	Integrated Concepts and Research Corporation
IHA	Incidental Harassment Authorization
JBER	Joint Base Elmendorf-Richardson
KABATA	Knik Arm Bridge and Toll Authority
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
LOA	Letter of Authorization
MLLW	Mean Lower Low Water
MMPA	Marine Mammal Protection Act
MOA	Municipality of Anchorage

µPa	microPascal(s)
mph	mile(s) per hour
mm	millimeter(s)
MTRP	Marine Terminal Redevelopment Project
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
OSP	Optimum Sustainable Population
PCE	Primary Constituent Element
POA	Port of Anchorage
PTS	Permanent Threshold Shift
rms	root mean square
SEL	Sound Exposure Levels
SPL	Sound Pressure Levels
SPT	Standard Penetration Test
TL	Transmission Loss
TTS	Temporary Threshold Shift
URS	URS Corporation
USACE	U.S. Army Corps of Engineers

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SECTION 1.0

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 United States 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. The 14 items are addressed in **Sections 1** through **14** of this Application for an IHA.

The Municipality of Anchorage (MOA), through its Port of Anchorage (POA) department, requests an IHA for the take of small numbers of marine mammals, by Level B behavioral harassment only, incidental to implementation of a Test Pile Program, including geotechnical characterization of pile driving sites, near its existing facility in Anchorage, Alaska. The POA requests that the IHA be valid for 1 year, from 01 April 2016 through 31 March 2017.

The Port is located on Knik Arm in upper Cook Inlet. It provides critical infrastructure for the citizens of Anchorage and a majority of the citizens of the State of Alaska. Approximately 74 percent of all non-fuel freight moving through Southcentral Alaska is transported through the POA. The POA moves approximately 30 percent of all refined petroleum product consumed in the state (not including the panhandle) and 95 percent of all refined product moving through Southcentral ports (McDowell 2015). It is a Defense Designated National Strategic Seaport. The existing marine-side infrastructure and support facilities at the POA are in need of repair or replacement because of their age, condition, or functional obsolescence. None of the existing wharves are constructed to current seismic standards. Plans for modernization include replacing pile-supported infrastructure and providing new seismically resistant berthing facilities for the existing tenants.

1.2 Project Purpose and Description

The POA is identifying and updating plans for modernizing its facilities through the Anchorage Port Modernization Project (APMP). Located within the Municipality of Anchorage (MOA) on Knik Arm in upper Cook Inlet (**Figure 1-1**), the existing 129-acre Port facility is currently operating at or above sustainable practicable capacity for the various types of cargo handled at the facility. The existing infrastructure and support facilities were largely constructed 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 regards to seismic design criteria and condition. The APMP 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.

An initial step in the APMP is implementation of a Test Pile Program, the proposed action for this IHA application, which involves the installation of 10 indicator test piles in the area of future APMP development. The Test Pile Program has several integrated purposes. One purpose is to inform and support the design of the APMP by using indicator piles to collect design load information and evaluate pile drivability and other pile installation variables along the length of the planned APMP wharf alignment.

The Test Pile Program necessarily replicates the pile driving conditions that may be used by constructors in the future APMP. As will be verified in the pile test, it is expected that the required bearing capacity of the piles will be achieved by embedment into the till layer beneath the inlet's silt and stiff clay deposits. The energy required to drive the 48-inch diameter piles with shoes through the depth of overburden materials is significant and would not likely be accomplished by most available vibratory equipment. Driving efficiency, constructability and production costs, along with the predominance of marine industry standard equipment, may likely result in the need to use kinetic hammers to support the production work. Toward replicating production conditions, the use of a vibratory hammer by contractors is specified by the POA as allowable for up to the first fifty (50) feet of driving.

Installation of indicator piles will also provide the opportunity to collect empirical data on noise levels produced during pile-driving operations in the waters of Knik Arm. A series of tests on impulsive and vibratory driven piles will be performed using different pile hammer types and noise attenuation methods (encapsulated bubble curtains, resonance-based systems, and pile cushions), and noise levels produced by the mitigated piles and control piles will be recorded as part of a hydroacoustic monitoring program. Noise levels produced by the installation of each pile will be measured, analyzed, and evaluated to determine which noise attenuation method, or combination of methods, results in the greatest decrease in produced noise levels. Results from the hydroacoustic monitoring will then be used to assist in design decisions as well as to develop monitoring and mitigation methods to reduce impacts to marine mammals from future port modernization activities.

Although vibratory pile installation generally produces lower source noise levels than impact pile driving and does not rise to the threshold of Level A take under the MMPA, it is a continuous noise source that affects marine mammals over a larger area than does impact pile driving (Section 6), which can result in increased Level B harassment take (see Section 6.7.5 and Table 6-9). Vibratory pile installation can take longer per pile than impact installation, which can greatly increase the length of time over which in-water construction occurs, especially for larger projects, with resultant potential impacts to marine mammals. Increased time can also increase costs for a project. Mitigating noise from impact pile driving operations will likely decrease project costs while contemporaneously decreasing project length and decreasing impacts to marine mammals and other marine wildlife.

Proposed activities included as part of the Test Pile Program with potential to affect marine mammals within the waterways adjacent to the POA include vibratory and impact pile-driving operations. Such in-water activities could result in harassment to marine mammals as defined under the MMPA of 1972, as amended in 1994. Proposed project activities are described in detail in the following sections.

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

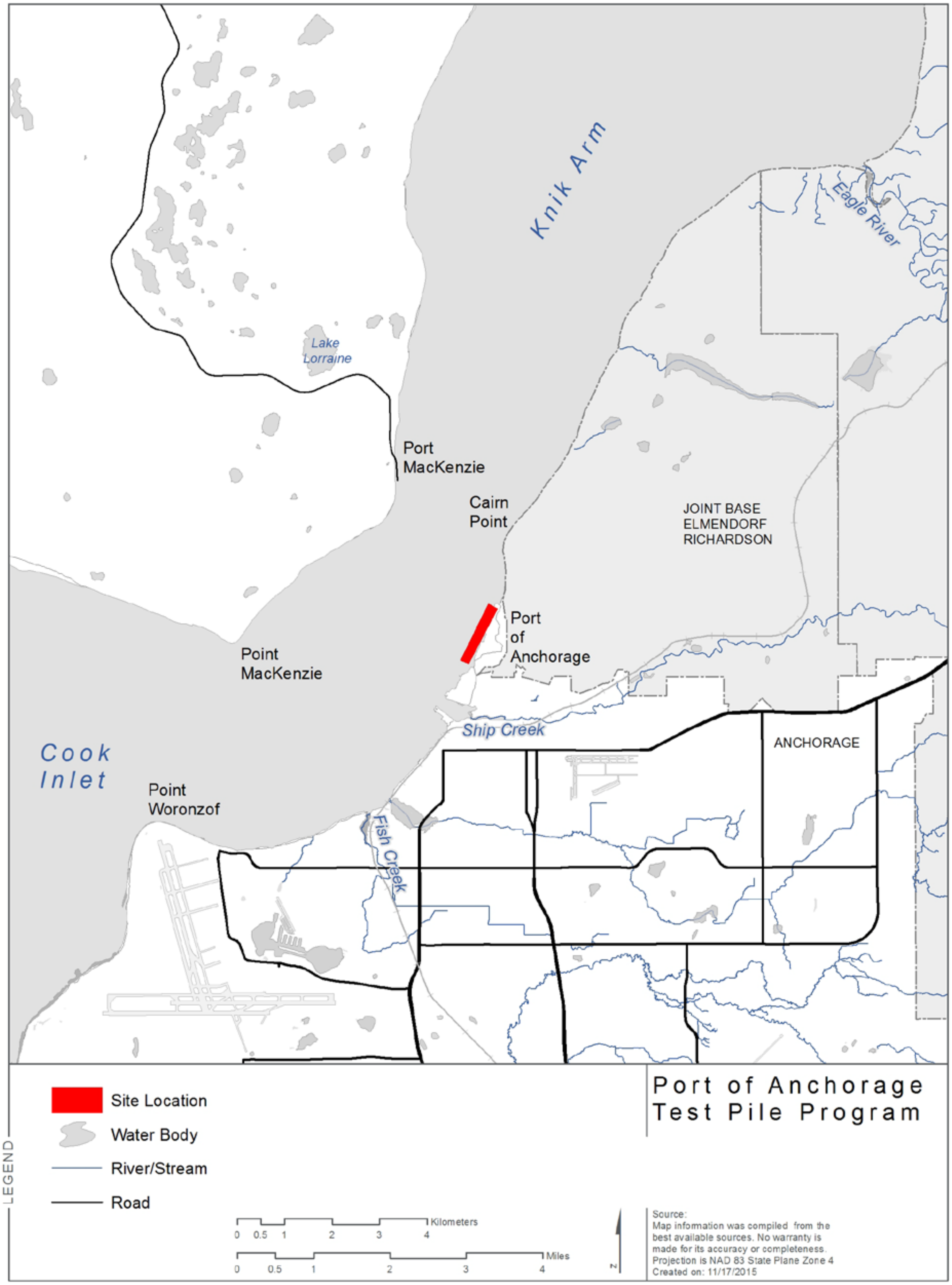

Figure 1-1 Site location and vicinity

1.3 Project Activities

The proposed action (the Test Pile Program) for this harassment authorization request is to install up to 10 test piles, gather geotechnical data near test pile locations, and measure in-water sound propagation parameters (e.g., transmission loss, water depth) during pile installation. Pile driving activities will occur in waters about 30 to 50 feet deep or less, and will be adjacent to the existing terminal deck or farther to the south of the existing terminal. Eight of the test piles will remain in place following installation, for future use as part of the APMP. Two test piles will be cut off at or below the mudline and removed in order to avoid interfering with U.S. Army Corps of Engineers dredging operations near the port. Geotechnical and sound propagation data collected during piling installation will be integrated into the design, construction, and environmental permit planning for the proposed APMP (**Figure 1-2**).

The POA proposes to install test piles in the location planned for the future APMP (**Figure 1-3**). The Test Pile Program will require a maximum of 31 days of pile driving, and up to 12 days of geotechnical sampling (via drilling or rod hammering). Hydroacoustic monitoring will be undertaken to assess the effectiveness of noise attenuation measures, and to monitor attenuated sounds associated with pile driving.

1.3.1 Pile-Driving Operations

The POA will drive ten 48-inch steel pipe indicator piles as part of the Test Pile Program. Installation of the piles will involve driving each pile with a combination of a large vibratory hammer and an impact hammer, or with only a very large impact pile hammer. It is estimated that vibratory installation of each pile will require approximately 30 minutes. For impact pile driving, pile installation is estimated to require between 80 to 100 minutes per pile, requiring 3,200 to 4,375 pile strikes. It is anticipated that an ICE 850 vibratory driver or equivalent hammer and a Delmag D100-13 diesel impact hammer or equivalent hammer will be required to install these piles. Pile driving will be halted during installation of each pile as additional pile sections are added. These shutdown periods will range from a few hours to a day in length to accommodate welding and inspections.

During the Test Pile Program, the contractor is expected to mobilize cranes, tugs, and floating barges, including one derrick barge up to 70 feet wide x 200 feet long. These barges will be moved into location with a tugboat. Cranes will be used to conduct overwater work from barges, which are anticipated to remain on-site for the duration of the Test Pile Program.

Figure 1-2 Footprint of the proposed Anchorage Port Modernization Project

Figure 1-3 Approximate locations of indicator piles

Sound attenuation measures will be used to test for achieved attenuation during pile-driving operations. The POA plans to test attenuation associated with the use of pile cushions, resonance-based systems, and bubble curtains (encapsulated or confined); however, the currents in the project area may preclude bubble curtain use if curtain frames cannot be stabilized during testing. If possible, the sound attenuation measures will be applied during specific testing periods, and then intentionally removed to allow comparison of sound levels during the driving of an individual pile. In this way, the sound signature of an individual pile can be compared with and without an attenuation device, avoiding the confounding factor of differences among piles. If sound attenuation measures cannot easily be added and removed, then different piles with and without sound attenuation measures will be compared. Data collected from sound attenuation testing will inform future construction of the APMP. The POA will monitor hydroacoustic levels, as well as the presence and behavior of marine mammals during pile installation.

Indicator Pile-Load Tests

Indicator pile-load testing involves monitoring installation of prototype piles as they are driven into the ground. Ten 48-inch piles will be driven for this test. It is expected that indicator pile tests will require approximately 4 weeks to complete. The objective of the indicator pile tests is to obtain representative pile installation and capacity data near the area of the future pier-head line. The indicator piles will be vibrated and impact-driven to depths of 175 feet or more from a large derrick barge. The size of the derrick barge will be approximately 70 feet wide x 200 feet long, and the barge will require approximately 12 feet of water under the barge bottom. The barge will not be grounded at any time, but rather anchored in position using a combination of anchor lines and spuds (two to four, depending on the barge). It is anticipated that the derrick barge will be towed from Seattle, or some other location along the West Coast, by a large tug.

Indicator piles will be installed adjacent to or shoreward of the existing wharf face. The selected locations (**Figure 1-3**) provide representative driving conditions, and enable hydroacoustic measurements in water depths and locations that closely approximate production locations.

Each indicator pile will take approximately 1 to 2 hours to install. However, indicator test pile locations may be as much as 500 feet apart. Therefore, the time required to mobilize equipment to drive each indicator pile will likely limit the number of piles driven to one, or perhaps two, per day.

Indicator piles 1 and 2 (**Figure 1-3**), which will be placed outside of the U.S. Army Corps of Engineer's dredging prism, will be cut off at or below the mudline immediately after being driven to their final depth. These measures will ensure that the piles do not interfere with dredging and POA operations. The eight remaining indicator piles will be allowed to settle for approximately 30 days and then will be subjected to a maximum of 10 restrikes each, for a total of 80 combined restrikes. No sound attenuation measures will be used during the restrikes, as the actual time spent re-striking piles will be minimal (approximately five minutes per pile). Section 1.4 contains the Test Pile Program's anticipated schedule.

Test Pile Program Demobilization

As explained above, indicator piles 1 and 2 will be cut off at or below the mudline immediately after being driven to their final depth. All other piles will remain in place throughout the APMP, with the intention of incorporating them into the new design if possible. If, when APMP construction nears completion, it is determined that the former indicator piles cannot be accommodated, the piles will be removed by cutting the piles at or below the existing mudline.

1.3.2 Geotechnical Characterization and Schedule

The POA proposes to complete geotechnical sampling at five overwater locations (**Figure 1-4**) to support the design and construction of the APMP. Explorations are proposed to be conducted in fall 2015 (**Table 1-1**), and will be conducted either from a barge or from the edge of the existing terminal wharf. The decision on whether to use a barge or the existing wharf will be made on the basis of access to the locations, tide and current constraints, and costs.

Figure 1-4 Locations for geotechnical sampling

Exploration equipment comprised of either a rotary drill rig or Cone Penetrometer Test (CPT) system will be used to perform the geotechnical sampling. This equipment will be located on the barge or wharf during the explorations. Methods used to conduct the sampling are described below.

- At each of the five geotechnical sampling locations (**Figure 1-4**), boreholes approximately 4 to 6 inches in diameter will be drilled to depths of 200 feet or more below the mudline using a rotary mud drill rig.
    - Each borehole will be drilled within a hollow 12-inch-diameter casing that extends from the barge or wharf to approximately 10 to 15 feet below the mudline. The casing separates the drilling accessories and samples from the aquatic environment to control and contain fluids and sediment.
    - The casing will be connected directly to either the barge or wharf, as applicable, and will prevent any materials from being discharged into waters of the U.S.
    - Soil samples will be collected at 5- to 10-foot intervals during the exploration. The sampling sequence will involve rotary drilling for 5 or 10 feet, and then obtaining a soil sample using either a thin-wall sampling tube or a Standard Penetration Test (SPT) sampler.
        - The thin-wall sampling tube sampler is a 3-inch-diameter by 30-inch-long steel tube that is pushed into the ground with hydraulics mounted on the drill rig. This approach involves little if any noise because of its very slow rate of advance.
        - The SPT requires hammering on a steel drill rod (**Figure 1-5**; figure does not show 12-inch casing). The SPT will be conducted by using equipment that conforms to American Society for Testing and Materials International Standard D1586. This standard involves use of a 140-pound hammer dropping 30 inches onto a 3-inch-diameter steel rod. The energy associated with the hammer is 375 foot pounds, significantly less than the energy from pile-driving hammers, which is usually greater than 100,000 foot pounds.
- Cone Penetrometer Test (CPT) soundings may be conducted at some locations to obtain a semi-continuous plot of soil resistance to penetration of a nominal 1.5- to 2-inch diameter rod. Information from the CPT sounding is used to interpret soil types and estimate engineering properties of the soil.
    - CPT sampling is typically conducted with a blunt-tipped rod that is hydraulically “pushed” into the substrate at a rate of 2 centimeters (0.79 inch) per second (**Figure 1-6**). No impact hammering is required. In-water noise associated with CPT sampling is expected to imperceptible.
    - Rods will be pushed to the point of refusal, which is expected to be approximately 45.72 meters (150 feet) below the mudline, depending on conditions.

- Rods will be enclosed within casings of the same type as used for the geotechnical sampling, and removed completely when testing is complete.
- One or more CPT soundings may be conducted at each geotechnical sampling location. The rods will likely be hydraulically pushed continuously to 30.5 meters (100 feet) or refusal.

Table 1-1 Project schedule for geotechnical sampling

Test Type	Number of Piles or Rods	Pile Type	Impact Pile-Driving Days	Drilling Days	Anticipated Start Date	Anticipated End Date
Geotechnical borehole drilling and CPT soundings[a]	5	Drill rod	-	12[b]	Fall 2015	19 days after start
Geotechnical SPT	5	Drill rod	12[b]	-	Fall 2015	19 days after start

[a] CPT sounding rods will be installed through use of hydraulic jacks to "push" the rod into the substrate.

[b] In-water drilling, hammering and CPT soundings will occur over the same 12-day test period. Though the testing period may require up to 4 days for each of the five test sites, it is estimated that only 2 drilling/hammering days will be required for each site, and mobilization at or between sites will occur over the remaining days.

Notes: CPT – Cone Penetrometer Test; SPT – Standard Penetration Test.

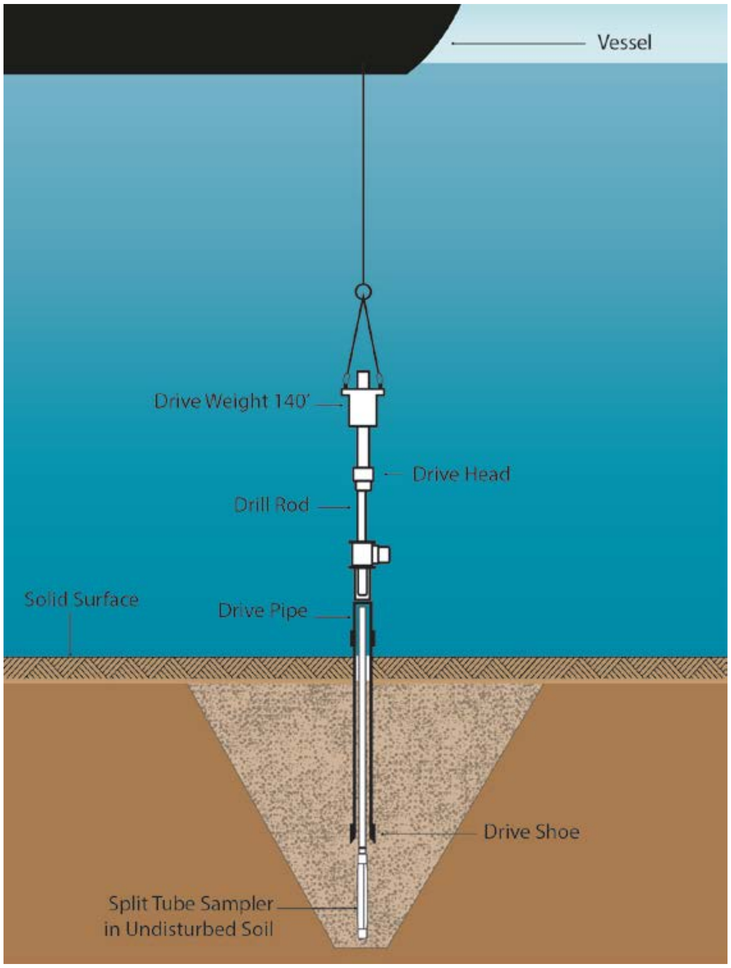

Figure 1-5 Collection of a soil sample using a typical Standard Penetration Test (SPT) sampler in the marine environment

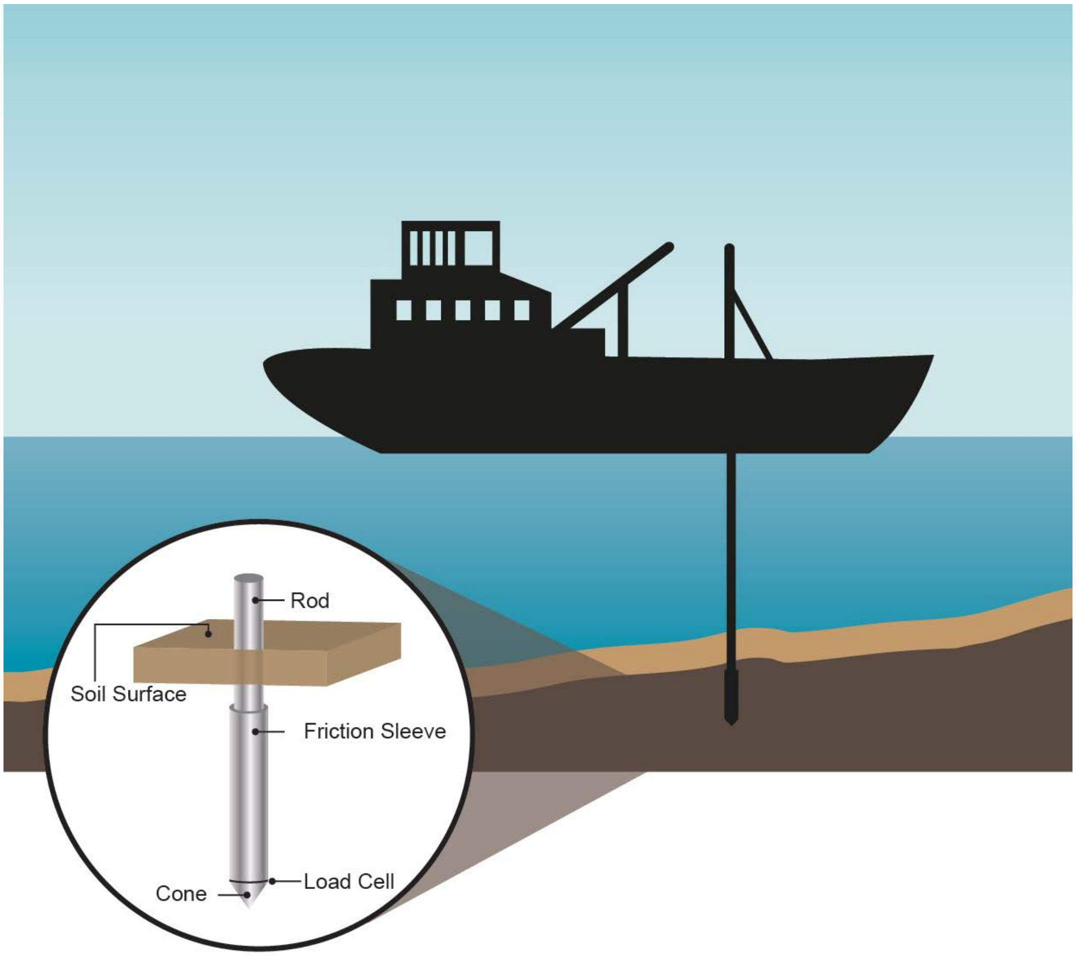

Figure 1-6 Collection of typical Cone Penetrometer Test (CPT) soundings in the marine environment

1.3.3 Hydroacoustic monitoring

One of the key objectives of the Test Pile Program is to quantify hydroacoustic noise resulting from pile installation and to evaluate methods that can be used to mitigate the noise during future APMP development. Currents in Knik Arm are expected to disperse bubbles produced by standard, unconfined bubble curtains, effectively reducing noise attenuation potential. Therefore, use of a method with a frame for confining bubbles is proposed for hydroacoustic testing. Although the exact method has not yet been identified, it will involve installing some kind of an outer casing around the pile between the water surface and the mudline and then releasing bubbles within the annulus between the outer casing and pipe perimeter. Also proposed for testing is a resonance-based sound attenuation system. This type of system uses noise-canceling resonating slats around the pile being driven to reduce noise levels from pile driving. In combination with these methods, the contractor may use pile cushions between the hammer and the steel pile for impact hammering. The intent of the pile cushion would be to lessen the level of sound produced by contact between the hammer and the pile.

Hydroacoustic monitoring will be conducted for all the piles driven for the Test Pile Program. Noise attenuation will be monitored with and without sound attenuation measures in operation. Underwater acoustic monitoring will include placing hydrophones within a clear acoustic line-of-sight to the test pile. There will be three locations for monitoring each test pile: two stationary positions, one close in and one distant, and one boat-based position. There may be the need for a second boat-based system to assist in mapping the marine mammal Level B harassment and Level A injury zones. Details of the hydroacoustic monitoring plan are provided in **Section 13** of the application.

1.4 Project and Pile-Driving Schedule

In-water work associated with the APMP Test Pile Program will begin no sooner than 01 April 2016 and will be completed no later than 31 March 2017 (1 year following IHA issuance; **Table 1-1** and **Table 1-2**). Pile driving is expected to take place over approximately 31 non-consecutive days for installation and restriking of all 10 piles for the Test Pile Program. A 25 percent contingency has been included in the 31 day schedule to account for schedule delays due to weather or marine mammal shutdowns. Approximately 25 percent of pile installation will be vibratory and the remaining 75 percent of installation will be conducted with impact hammers. Although each indicator pile test can be conducted in less than 2 hours, mobilization and setup of the barge at the test site will require 1 to 2 days per test pile and could be longer depending on terminal use. Additional time will be required for installation of sound attenuation measures, and for subsequent noise-mitigation monitoring. Hydroacoustic monitoring and installation of resonance-based systems or bubble curtains will likely increase the time required to install a specific indicator pile from a few hours to a day or more.

Approximately 12 days of drilling and SPT hammering will be required for geotechnical studies. It is important to note that the days for pile driving and geotechnical explorations will not overlap or be successive because geotechnical exploration will take place in the fall of 2015.

Within any day, the number of hours of pile driving will vary, but will generally be low. The number of hours required to set a pile initially using vibratory methods is about 30 minutes per pile, and the number of hours of impact driving per pile is about 1.5 hours. On some days, pile driving will occur only for an hour or less as bubble curtains and the containment frames are set up and implemented, resonance-based systems are installed, hydrophones are placed, pipe segments are welded, and other logistical requirements are handled. Potential scheduling issues or weather-related delays may also occur. Therefore, an additional 25 percent contingency was added to hourly estimates of pile-driving hours to account for the intermittent nature of this activity (**Table 1-2**). The take estimates provided in **Section** 6 are based upon the contingency-added estimates of hours required for pile driving.

Table 1-2 Conceptual Project Schedule for test pile driving, including estimated number of hours and days for pile driving

Month[a]	Pile Type	Pile Diameter	Number of Piles	Number of Hours, Vibratory Driving[b]	Number of Hours, Impact Driving[b]	Number of Days of Pile Driving	Number of Days of Restrikes	Total Number of Days of Pile Driving
April – July 2016	Steel pipe	48" OD	10	5	17	21	4	25
				+ 25% contingency =				
				6 hours	**21 hours**	**26 days**	**5 days**	**31 days**

[a] Note that schedule assumes permit approvals by April 2016. If authorization is delayed, the schedule would be delayed accordingly, pending the approvals of all applicable permits. Therefore, pile installation may occur during any 4 consecutive weeks following authorization. Restriking will take place approximately 30 days later.

[b] Regarding the number of hours, some pile-driving days will require an hour or less of pile installation in consideration of factors including mobilization of sound attenuation measures, hydrophone placement, etc. The APMP Test Pile Program will require a small amount of pile installation, sparsely distributed over a period of approximately 4 weeks.

Notes: OD – outside diameter.

1.5 Applicable Permits/Authorizations

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

- U.S. Army Corps of Engineers (USACE) Section 10 Permit

2 Dates, Duration, and Geographical Region of Activities

2.1 Dates and Durations of Activities

The POA is planning for the Test Pile Program to take place from approximately 01 April 2016 to 01 July 2016, while geotechnical sampling will occur in fall of 2015.. However, due to unexpected project delays and other unforeseeable circumstances, the requested authorization period for the Test Pile Program is for the 1-year period from 01 April 2016 to 31 March 2017.

2.2 Geographical Setting

The following sections describe the overall geographic region of the Test Pile Program site, comprised of the physical, acoustical, and biological environment. 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**).

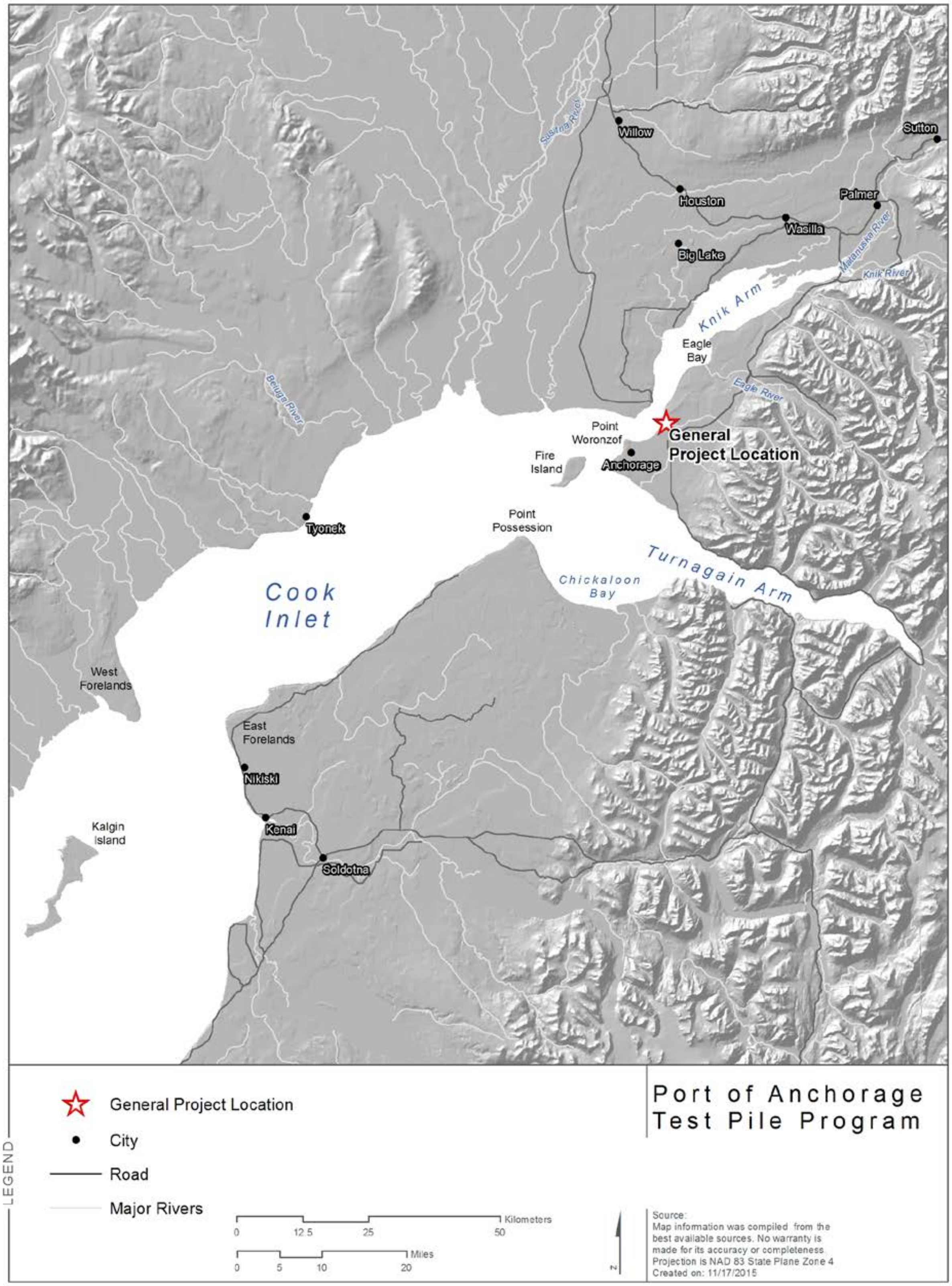

Figure 2-1 Overview of Knik Arm and upper Cook Inlet

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 with magnitudes 6.0 to 8.8; has some of the highest tides in North America (NOAA 2015), which are the driving force of surface circulation, and contains substantial quantities of mineral resources, including coal, oil, and natural gas. During winter months, sea, beach, and river ice are dominant physical forces within Cook Inlet. In the upper Cook Inlet, sea ice generally forms in October to November, and continues to develop through February or March (Moore et al. 2000).

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-size 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 the Knik Arm during summer months. Smaller rivers and creeks also enter along the sides of Knik Arm (summary from USDOT & 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 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 over 12.50 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 to the system (Ebersole and Raad 2004). Natural sedimentation processes act to continuously infill the dredged basin each spring and summer season.

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. Ship Creek, stocked twice each summer, serves as an important recreational fishing resource. Ship Creek flows into Knik Arm through the MOA industrial area; the mouth is approximately 0.6 kilometers (0.4 miles) south of the southern end of the project area. JBER is 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 (see **Section 6.4**). 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 probing study for the POA's Marine Terminal Redevelopment Project (MTRP) site ranged from 105 dB to 135 dB (URS 2007). The ambient background sound pressure levels (SPLs) obtained in that study were highly variable. Most SPL recordings exceeded 120 dB. Background sound levels measured in 2008 at the MTRP site ranged from 125 dB to 155 dB (SFS 2008). 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. Therefore, these 2008 sound levels portray an accurate picture of background sound levels in Knik Arm near the POA.

2.2.3 Essential Fish Habitat

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH, "waters" include aquatic areas that are used by fish and their associated physical, chemical, and biological properties and may include 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 a healthy ecosystem. "Spawning, breeding, feeding, or growth to maturity" covers a species' entire life cycle.

NMFS and the North Pacific Fishery Management Council identified EFH in upper Cook Inlet for five species of anadromous Pacific salmon; however, no salmon species that would be adversely affected by the Test Pile Program are listed under the ESA. Designated EFH present in the vicinity of the POA is for both juvenile and adult life stages of Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), sculpins (Cottidae spp.), and eulachon (also called hooligan and candlefish). In addition, streams, lakes, ponds, wetlands, and other water bodies that currently support or historically supported anadromous fish species (e.g., salmon) are considered freshwater EFH. 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. Details of EFH and the life stage of these species can be found in the "Knik Arm Crossing Essential Fish Habitat Assessment of the Proposed Action" and are incorporated by reference (KABATA 2006). An additional draft EFH assessment will be submitted to NMFS by the POA for the Test Pile Program (HDR 2015) as part of the USACE Section 10 permit application.

2.2.4 Fish

Knik Arm supports 14 to 18 species of fish, including sticklebacks (*Gasterosteus* spp.), sculpins, cod, Pacific herring (*Clupea pallasii*), and five species of salmon (Moulton 1997; Pentec 2004a, 2004b, 2004c, 2004d, 2004e, 2005a, 2005b). The intertidal and subtidal (submerged) habitats directly surrounding the POA are covered in shallow waters, with tidal flats present at the higher elevations. Habitat surveys indicate that the area immediately around the POA supports a wide diversity of marine and anadromous fish species and provides migration, rearing, and foraging habitat. Shallow waters along the tidal flats of Knik Arm are used by all five species of Pacific salmon (*Oncorhynchus* spp.), saffron cod (*Eleginus gracilis*), and a variety of prey species such as eulachon (*Thaleichthys pacificus*) and longfin smelt (*Spirinchus thaleichthys*) (Moulton 1997; Pentec 2004a, 2004b, 2005a, 2005b). Many of these species provide recreational and commercial sport fishing and serve as prey for larger fish and marine mammals.

All species of fish in this area play an important role in the diets of marine mammals, and are important to recreational sport fishing as catch or prey. The fish resources of upper Cook Inlet are characterized primarily by the spring to fall availability of migratory eulachon, out-migrating salmon smolt, and returning adult salmon. Species abundance and distribution vary greatly throughout the summer (Moore et al. 2000).

Juvenile salmon were the most abundant fishes captured in summer, with increasing abundance of Chinook (*Oncorhynchus tshawytscha*) and pink salmon (*O. gorbuscha*) beginning in April, peaking in May, and then sharply declining in July (Pentec 2005). Coho salmon (*O. kisutch*), and to a lesser degree sockeye salmon (*O. nerka*), had the largest and longest presence in Knik Arm of all juvenile salmonids. Coho was the most abundant juvenile salmonid captured in April, increasing to a peak in August (in 2005) before declining. Coho maintained a presence in the nearshore Knik Arm through November in 2004. Few sockeye were observed before May but were more abundant from June through August, before numbers declined in September and October (Pentec 2005).

Stomach content analysis of 39 juvenile Chinook salmon captured from Knik Arm found that important prey included aphids; mysid crustaceans; adult and larval forms of aquatic insects from the orders Ephemeroptera (mayflies), Plecoptera (stone flies), and Diptera (true flies); and a marine nereid polychaete worm (*Neanthes limnicola;* Pentec 2005). Chum and rainbow trout (*O. mykiss*) stomach contents contained a similar mix of amphipods, other crustaceans, and insects. The extreme turbidity and poor visibility in Knik Arm likely severely limits the success of visual feeding by fish, but visual feeding may be possible in microhabitats within the surface waters in Knik Arm where short periods (minutes) of relative quiescence in the generally turbulent water allow partial clearing (Pentec 2005). During the study, surface feeding by saffron cod was observed where they appeared to be feeding on crustaceans in the clearer surface water microhabitats. The authors hypothesized that juvenile salmonids may be able to feed in these small lenses of clearer waters where prey can be seen, which can occur along shorelines as well as in the middle of Knik Arm.

Tow-net sampling has shown substantial presence of juvenile salmonids in the open waters of Knik Arm during the spring (Houghton et al. 2005). Data from Pentec (2005) and those of Moulton (1997) collected in offshore surface waters of upper Cook Inlet, south of Fire Island, suggest that juvenile salmon do not favor shorelines, as many of these fish, including many small individuals (e.g., chum and sockeye less than 50 millimeters (1.97 inches) in length) appeared to have very full stomachs. However, adult salmon displayed orientation to the narrow inshore areas, where they may gain some refuge from beluga whale predation (Pentec 2005).

Juvenile salmonids are reared at the William Jack Hernandez Sport Fish Hatchery for up to 2 years prior to release at the smolt stage. Many of the smolts released from the hatchery reside in the Ship Creek area for a limited period of time before out-migrating to other parts of Knik Arm and Cook Inlet. Juvenile Chinook salmon captured from between Cairn Point and Point Woronzof were primarily of Ship Creek hatchery origin.

2.2.5 Zooplankton and Invertebrates

Fish and benthos sampling was conducted around the POA and north to Eagle Bay during July through November 2004, and from April through September 2005 (Houghton et al. 2005, Pentec 2005). These studies concluded that the area around the POA supported 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.

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*) and Steller sea lions (*Eumetopias jubatus*; **Table 3-1**). Marine mammals that occur in Cook Inlet that are not expected to be observed in the POA area include the humpback whale (*Megaptera novaeangliae*), gray whale (*Eschrichtius robustus*), minke whale (*Balaenoptera acutorostrata*), and Dall's porpoise (*Phocoenoides dalli*). With very few exceptions, these species do not occur in upper Cook Inlet and they will therefore not be considered further in this application. The population estimate of 340 individuals for the Cook Inlet beluga whale is only for Cook Inlet, since the stock is assumed to reside in Cook Inlet year-round. The population estimate for resident killer whales is for the Eastern North Pacific stock, whereas the estimate for the transient population is for the Gulf of Alaska, Aleutian Islands, and Bering Sea stocks, both of which overlap the Cook Inlet area. The population estimate for the harbor seal includes Cook Inlet and the Shelikof Strait area. Except for the beluga whale and harbor seal, very small proportions of the populations for the other species occur in Cook Inlet and even fewer in upper Cook Inlet near the project site. This application assesses the potential impacts of the project on these five species, which are discussed more fully in **Section** 4.

Table 3-1 Marine mammals in the project area

Species or DPS	Abundance	Comments
Cook Inlet beluga whale (*Delphinapterus leucas*)	340[a]	Occurs in the project area. Listed as Depleted under the MMPA, Endangered under ESA.
Killer (Orca) whale (*Orcinus orca*)	2,347 Resident 587 Transient[b]	Occurs rarely in the project area. No special status or ESA listing.
Harbor porpoise (*Phocoena phocoena*)	31,046[c]	Occurs occasionally in the project area. No special status or ESA listing.
Harbor seal (*Phoca vitulina*)	22,900[d]	Occurs in the project area. No special status or ESA listing.
Steller sea lion (*Eumetopias jubatus*)	55,422[e]	Occurs rarely within the project area. Listed as Depleted under the MMPA, Endangered under ESA.

[a] Abundance estimate for the Cook Inlet stock.

[b] Abundance estimate for the Eastern North Pacific Alaska Resident stock; the estimate for the transient population is for the Gulf of Alaska, Aleutian Islands, and Bering Sea stocks.

[C] Abundance estimate for the Gulf of Alaska stock.

[d] Abundance estimate for the Cook Inlet/Shelikof stock.

[e] Abundance estimate for the Western U.S. Stock.

Source for Cook Inlet beluga population estimate: Shelden et al. 2015. Sources for other population estimates: Allen and Angliss 2013, 2014, 2015.

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SECTION 4.0

4 Affected Species Status and Distribution

4.1 Harbor Seal

4.1.1 Status and Distribution

Harbor seals range from Baja California north along the west coasts of Washington, Oregon, California, British Columbia, and Southeast Alaska; west through the Gulf of Alaska, Prince William Sound, and the Aleutian Islands; and north in the Bering Sea to Cape Newenham and the Pribilof Islands. There are 12 recognized stocks in Alaska. Distribution of the Cook Inlet/Shelikof stock extends from Seal Cape (Coal Bay) through all of upper and lower Cook Inlet. The Cook Inlet/Shelikof stock is estimated at 22,900 individuals (Allen and Angliss 2013). Harbor seals are taken incidentally during commercial fishery operations at an estimated annual mortality of 24 individuals (Allen and Angliss 2013). The estimated average annual subsistence harvest of the Cook Inlet/Shelikof stock is 439 individuals (Allen and Angliss 2013).

Harbor seals haul out on rocks, reefs, beaches, and drifting glacial ice (Allen and Angliss 2013). They are non-migratory; their local movements are associated with tides, weather, season, food availability, and reproduction, as well as sex and age class (Allen and Angliss 2013; Boveng et al. 2012; Lowry et al. 2001; Small et al. 2003).

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). Their diet consists of fish and invertebrates (Orr et al. 2004), including capelin, eulachon, cod, pollock, flatfish, shrimp, octopus, and squid. Researchers have found that they complete both shallow and deep dives during hunting, depending on the availability of prey (Tollit et al. 1997).

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 a higher usage than the eastern coast habitats, and seals generally remained south of the Forelands if captured in lower Cook Inlet (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 haul-out 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 occasionally observed in Knik Arm and in the vicinity of the POA, primarily 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).

During construction monitoring conducted at the POA from 2005 through 2011, harbor seals were observed from 2008 through 2011; data were unpublished for years 2005 through 2007 (**Table 4-1**) (Cornick et al. 2011; Cornick and Saxon-Kendall 2008, 2009, 2010; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). Harbor seals were documented during scientific and construction monitoring efforts in 2008. One harbor seal was sighted in Knik Arm on 13 September 2008, traveling north in the vicinity of the POA. In 2009, harbor seals were observed in the months of May through October, with the highest number of sightings being 8 in September (Cornick et al. 2010; ICRC 2010a). There were no harbor seals reported in 2010 from scientific monitoring efforts; however, 13 were reported from construction monitoring. In 2011, 32 sightings of harbor seals were reported during scientific monitoring, with a total of 57 individual harbor seals sighted. Harbor seals were observed in groups of one to seven individuals (Cornick et al. 2011). There were only 2 sightings of harbor seals during construction monitoring in 2011 (ICRC 2012).

Table 4-1. Summary of harbor seals documented during previous POA monitoring effort

Year	Monitoring Effort			Total # of Sightings	Total # of animals	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	231	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	1202	32	57	POA: Scientific Monitoring
2011	July 17–Sept. 27	16	NA	2	2	POA: Construction Monitoring

[a] In-water pile-driving hours.

[b] Additionally, three unidentified pinnipeds were documented.

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

Notes: NA - Not Available

4.1.5 Acoustics

Harbor seals respond to underwater sounds from approximately 1 to 180 kilohertz (kHz) with the 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). **Figure 4-1** is an in-air audiogram and **Figure 4-2** is an in-water audiogram for the harbor seal (taken from Nedwell et al. 2004). An audiogram shows the lowest level of sounds that the animal can hear (hearing threshold) at different frequencies (pitch). The y-axis of the audiogram is sound levels expressed in dB (either in-air or in-water) and the x-axis is the frequency of the sound expressed in kHz.

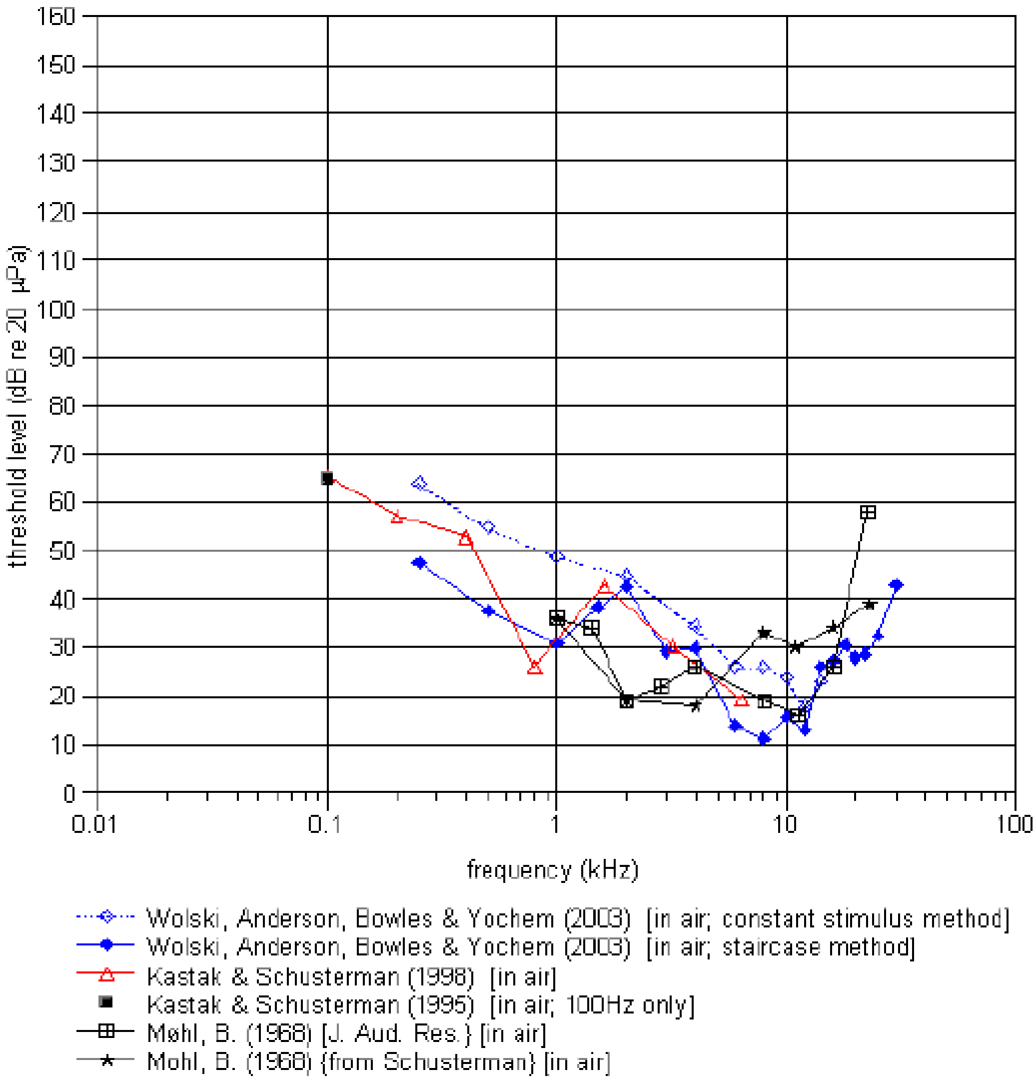

Figure 4-1 Harbor seal in-air audiogram (taken from Nedwell et al. 2004)

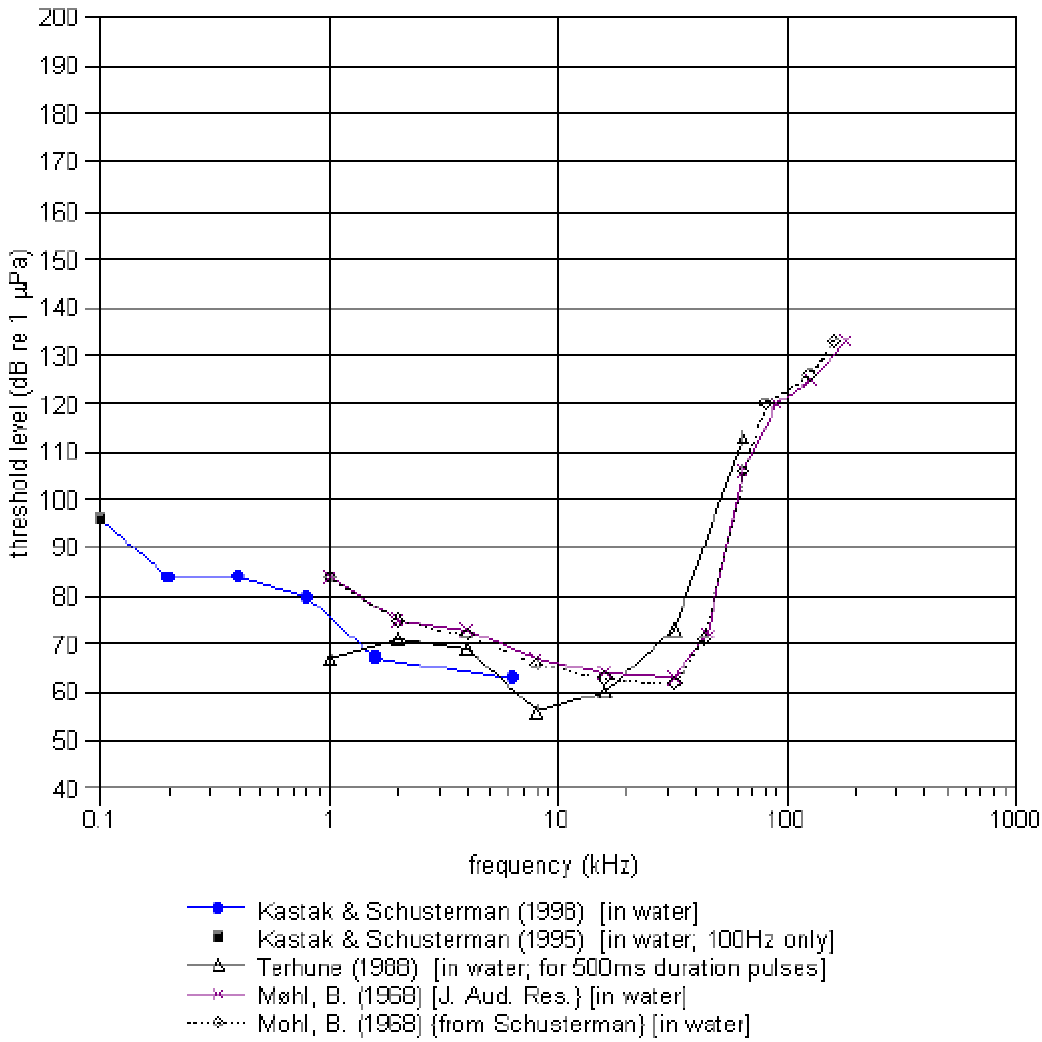

Figure 4-2 Harbor seal in-water audiogram (taken from Nedwell et al. 2004)

4.2 Steller Sea Lion

4.2.1 Status and Distribution

Two Distinct Population Segments (DPS) of Steller sea lions occur in Alaska: the western and 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 continued population decline resulted in a change in listing status to endangered in 1997. Since 2000, studies have documented a continued decline in the population in the central and western Aleutian Islands; however, the population east of Samalga Pass has increased and potentially is stable (Allen and Angliss 2014). This includes the population that inhabits Cook Inlet.

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 distributions 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 encountered 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 (Shelden et al. 2013).

4.2.4 Presence in Project Area

In June of 2009, a Steller sea lion was documented three times (within the same day) at the POA and was believed to be the same individual each time (ICRC 2009a). However, the occurrence of Steller sea lions in the project area is rare.

4.2.5 Acoustics

The hearing capabilities of Steller sea lions has been documented to be fairly similar to the hearing range of California sea lions with slight variations in males and females (Mulsow and Reichmuth 2008; Kastelein et al. 2005). **Figure 4-3** and **Figure 4-4** display in-water and in-air audiograms for California sea lions (Nedwell et al. 2004). Kastelein et al. (2005) documented that the best hearing range for Steller sea lions was 1 to 16 kHz.

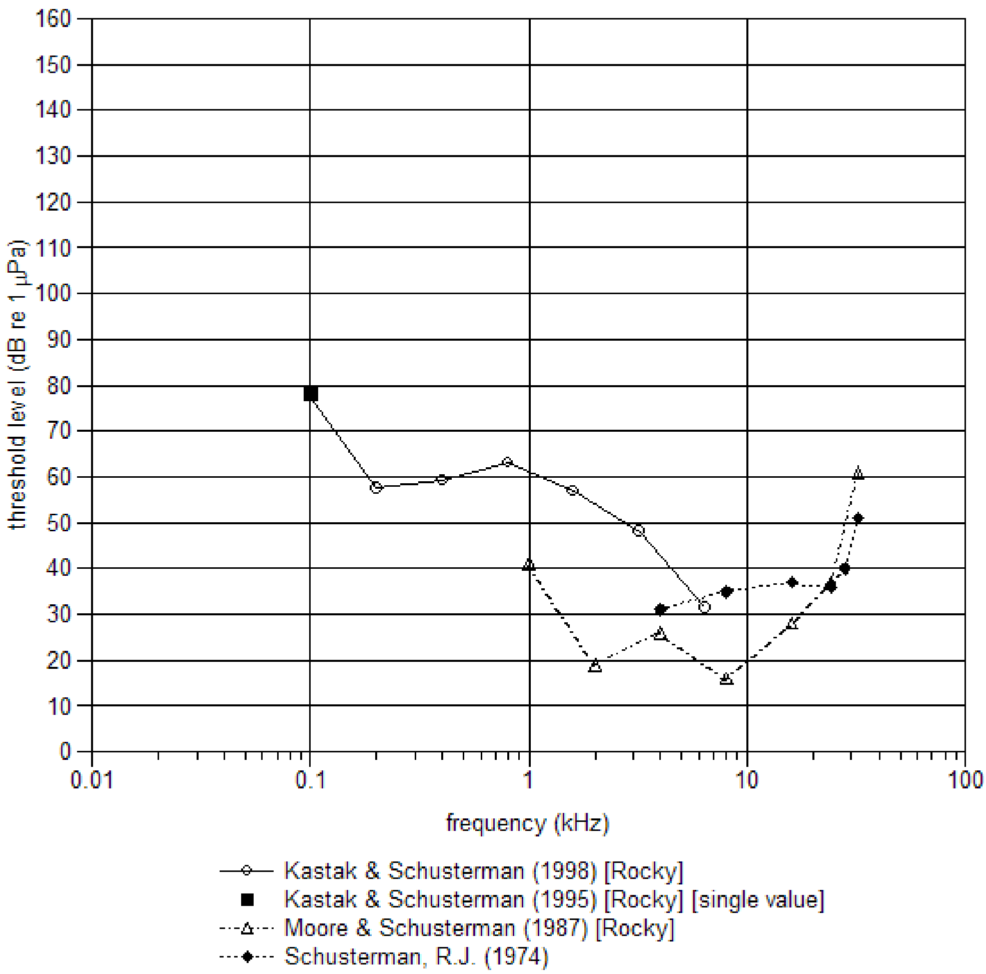

Figure 4-3 California sea lion in-air audiogram (taken from Nedwell et al. 2004)

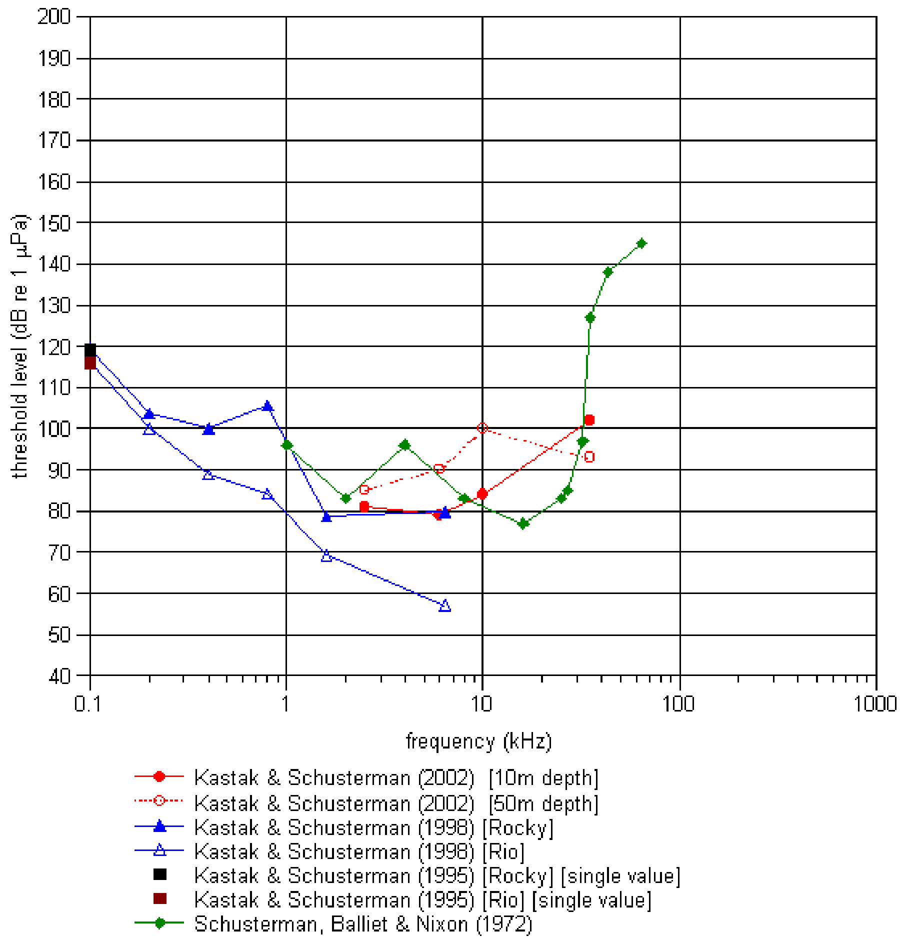

Figure 4-4 California sea lion in-water audiogram (taken from Nedwell et al. 2004)

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 is currently estimated at 31,046 individuals (Allen and Angliss 2014). NMFS suggests that a finer division of stocks is likely in Alaska (Allen and Angliss 2014). 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 have been documented to be heavily used by harbor porpoises in some years (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 2014).

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 the upper Cook Inlet between April and October, except for a recent survey that recorded higher numbers than what is considered typical. Highest monthly counts include 17 harbor porpoises reported for spring through fall 2006 by Prevel-Ramos et al. (2008), 14 for spring of 2007 by Brueggeman et al. (2007), 12 for fall of 2007 by Brueggeman et al. (2008a), and 129 for spring through fall in 2007 by Prevel-Ramos et al. (2008) between Granite Point and the Susitna River during 2006 and 2007; the reason for the recent spike in numbers (129) of harbor porpoises in the upper Cook Inlet is unclear and quite disparate with results of past surveys, suggesting it may be an anomaly. The spike occurred in July, which was followed by sightings of 79 harbor porpoises in August, 78 in September, and 59 in October in 2007. The number of porpoises counted more than once was unknown, indicating that the actual numbers are likely smaller than reported.

Harbor porpoises have been detected during passive acoustic monitoring efforts throughout Cook Inlet, with detection rates being 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, harbor porpoises were reported in 2009, 2010, and 2011 (Cornick and Saxon-Kendall 2008, 2009, 2010; Cornick et al. 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 occurring 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 Knik Arm 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 Harbor porpoise sightings in Knik Arm

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	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
2007	October	NA	NA	1	1	URS
2008	June 24–Nov. 14	86	612	0	0	POA: Scientific Monitoring
2008	July 24–Nov. 26	108	607[a]	0	0	POA: Construction Monitoring
2009	May 4–Nov. 18	86	783	0	0	POA: Scientific Monitoring
2009	March 28–Dec. 14	231	3,322[a]	NA	20	POA: Construction Monitoring
2010	June 29–Nov. 19	87	600	0	0	POA: Scientific Monitoring
2010	July 21–Nov. 20	106	862[a]	2	2	POA Construction Monitoring
2011	June 28–Nov. 15	104	1,202	5	6	POA: Scientific Monitoring
2011	July 17–Sept. 27	16	NA	0	0	POA: Construction Monitoring

[a] In-water pile-driving hours.

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

Notes: NA - Not Available.

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). **Figure 4-5** is an audiogram for the harbor porpoise (taken from Nedwell et al. 2004).

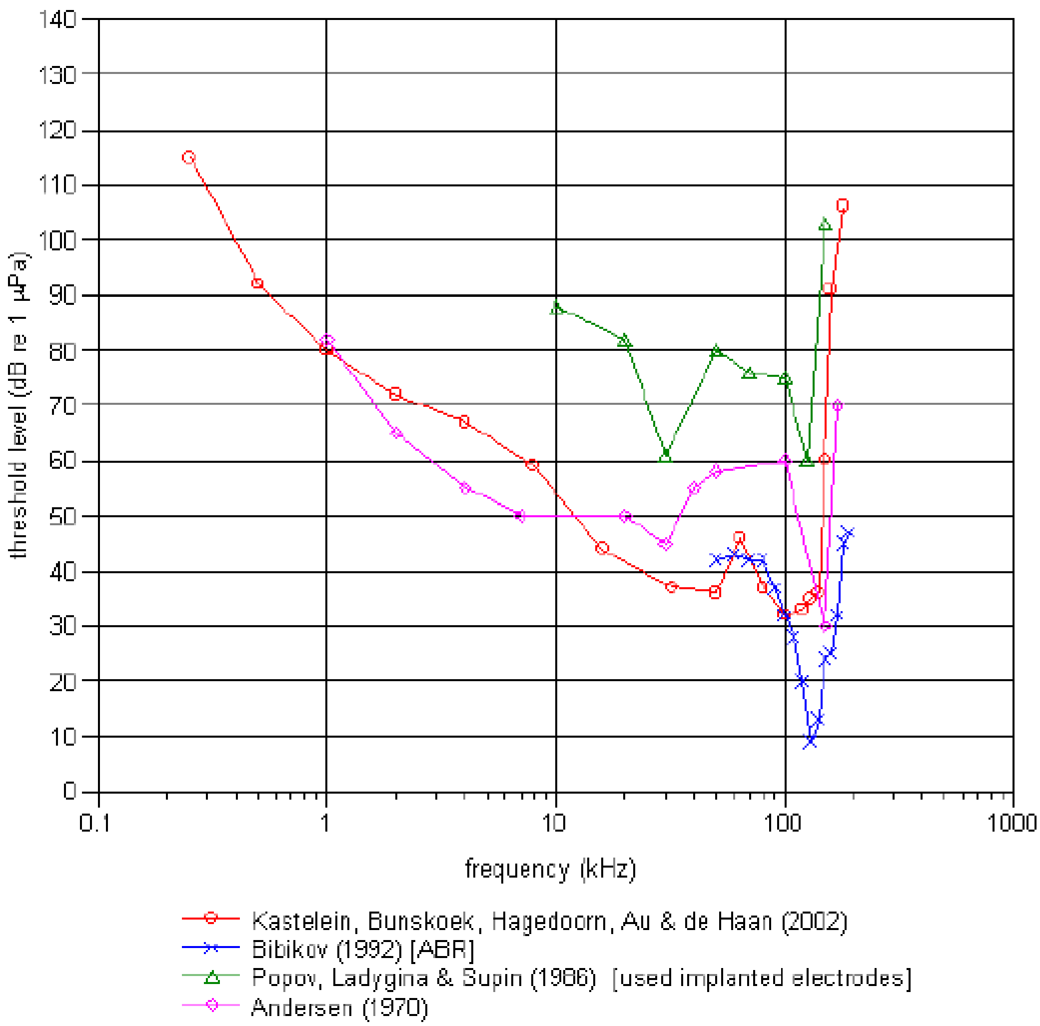

Figure 4-5 Harbor porpoise in-water audiogram (taken from Nedwell et al. 2004)

4.4 Killer Whale

4.4.1 Status and Distribution

The population of the North Pacific stock of killer whales contains an estimated 2,347 animals in the resident group and 587 animals in the transient group (Allen and Angliss 2014). Numbers of killer whales in Cook Inlet are small compared to the overall population, and most are recorded in lower Cook Inlet.

4.4.2 Foraging Ecology

Resident killer whales are primarily fish-eaters, while transients consume marine mammals. Both are occasionally found in Cook Inlet, where 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 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. Passive acoustic monitoring efforts throughout Cook Inlet documented killer whales at Beluga River, Kenai River, and Homer Spit, they were not encountered at any mooring within the Knik Arm. These detections were likely resident (fish-eating) killer whales. Transient killer whales (marine-mammal eating) were not believed to have 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 during recent 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 (Cornick and Pinney 2011; Cornick and Saxon-Kendall 2008; 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.

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, with the most sensitive range between 18 and 42 kHz. Their greatest sensitivity was at 20 kHz, which is lower than many other odontocetes, but it matches peak spectral energy reported for killer whale echolocation clicks. **Figure 4-6** is an audiogram for the killer whale (taken from Nedwell et al. 2004).

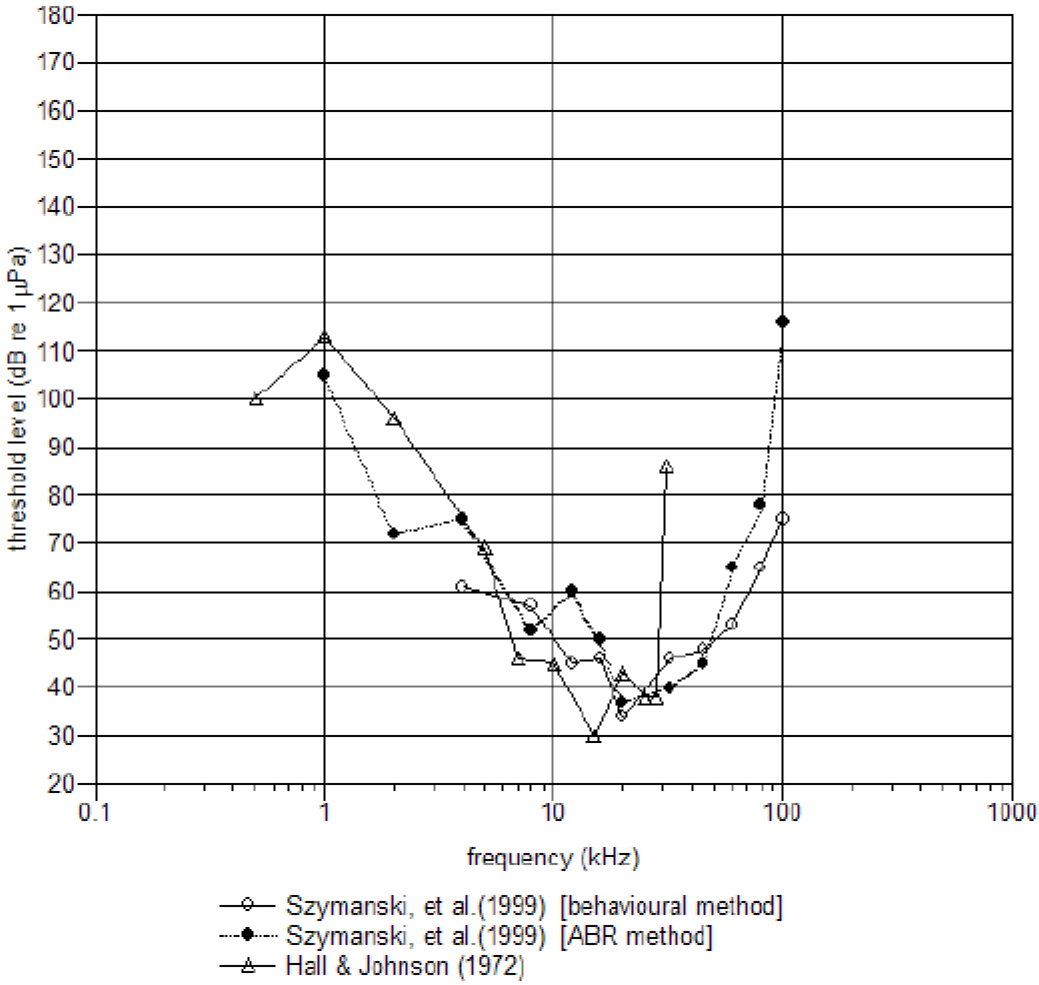

Figure 4-6 Killer whale in-water audiogram (taken from Nedwell et al. 2004)

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: 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). Only the Cook Inlet stock inhabits the project area.

Although the Alaska Department of Fish and Game (ADF&G) conducted a survey in August 1979, it did not include all of upper Cook Inlet, the area where almost all beluga whales are currently found during summer. However, 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 adopted 1,300 beluga whales as the carrying capacity in Cook Inlet (65 FR 34590).

NMFS began comprehensive, systematic aerial surveys on 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 conducted each June since 1999 indicate that the population has continued to decline from 2002-2012 at an annual rate of 0.6 percent (**Table 4-3**; Allen and Angliss 2014).

Table 4-3 Annual Cook Inlet beluga whale abundance estimates

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

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, 2006, 2007; Shelden et al.2013, 2015.

Cook Inlet beluga whales may have numbered fewer than several thousand animals, but there were no systematic population estimates prior to 1994. 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). This decision was upheld in court. 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 rose above 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 distinct population segment that is in danger of extinction throughout its range; NMFS issued a proposed rule to list the Cook Inlet beluga whale as an endangered species (72 FR 19821). Public hearings were conducted in July 2007, and the comment period extended to 03 August 2007. On 22 April 2008, NMFS announced that it would delay the decision on the proposed rule until after it had assessed the population status in the summer of 2008, moving the deadline for the decision to 20 October 2008 (73 FR 21578). On 17 October 2008, NMFS announced the listing of the population as endangered under the ESA (73 FR 62919).

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 4-7**). From spring through fall, Area 1 critical habitat has the highest concentration of beluga whales with important foraging and calving habitat.

Area 2 critical habitat has a lower concentration of beluga whales in the spring and summer, but is used by belugas in the 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 (PCE), 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 (Mean Lower Low water) and within 5 miles of high and medium flow anadromous fish streams.

2) Primary prey species include 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.

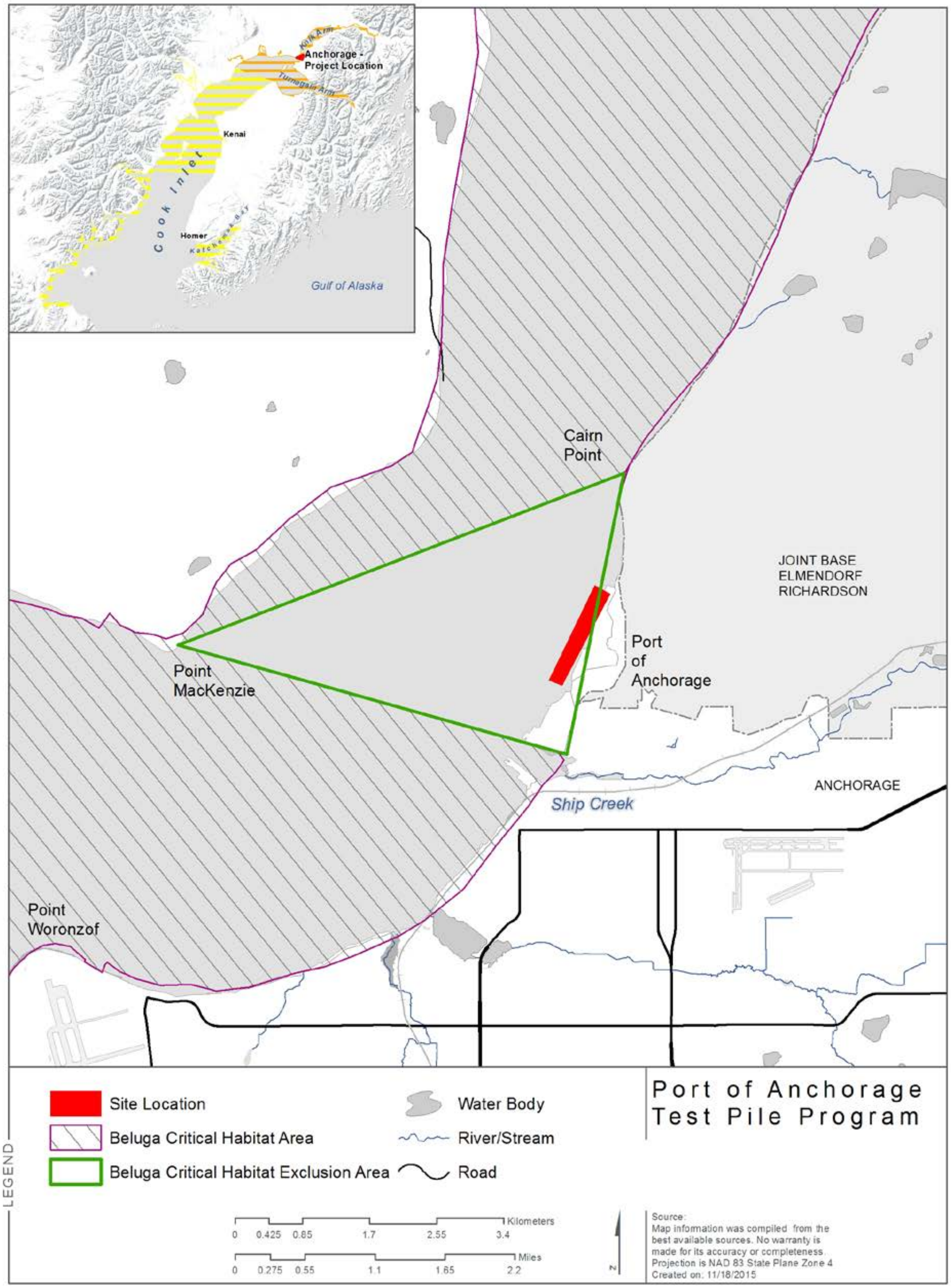

Figure 4-7 Beluga whale critical habitat and exclusion zone

4.5.2 Foraging Ecology

Hobbs et al. (2008) presents the most current analysis of stomach contents derived from stranded or harvested beluga whales in Cook Inlet. This analysis is continuing and provides information on prey availability and prey preferences of Cook Inlet beluga whales, which is summarized below.

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 species found in the stomachs of belugas may be from secondary ingestion by cods that feed on polychaetes, shrimp, amphipods, mysids, as well as other fish (e.g., walleye pollock and flatfish) and invertebrates.

From late spring and throughout 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). Five Pacific salmon species: Chinook, pink, coho, sockeye, and chum, spawn in rivers throughout Cook Inlet (Moore et al. 2000; Moulton 1997). Calkins (1989) recovered 13 salmon tags in the stomach of an adult beluga whale found dead in Turnagain Arm. Beluga whale hunters in Cook Inlet reported one whale having 19 adult Chinook salmon in its stomach (Huntington 2000). Salmon, overall, represent the highest percent frequency of occurrence of the 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.

In the 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. Bottom fish include Pacific staghorn sculpin, starry flounder, and yellowfin sole. Stomach samples from Cook Inlet beluga whales are not available for winter months (December through March), although dive data from belugas tagged with satellite transmitters suggest whales feed in deeper waters during winter (Hobbs et al. 2005), possibly on such prey species as flatfish, cod, sculpin, and pollock.

NMFS has characterized the relative value of four habitats as part of the management and recovery strategy in its Final Conservation Plan for the Cook Inlet beluga whale (NMFS 2008a). These are sites where beluga whales are most consistently observed, where feeding behavior has been documented, and where dense numbers of whales occur within a relatively confined area of the inlet. Type 1 Habitat is termed "High Value/High Sensitivity" and includes what NMFS believes to be the most important and sensitive areas of the Cook Inlet for beluga whales. Type 2 Habitat is termed "High Value" and includes summer feeding areas and winter habitats in waters where whales typically occur in lesser densities or in deeper waters. Type 3 Habitat occurs in the offshore areas of the mid and upper inlet and also includes wintering habitat. Type 4 Habitat describes the remaining portions of the range of these whales within Cook Inlet.

The habitat that will be directly impacted from Test Pile activities at the POA is considered Type 2 Habitat, although it lies within the zone that was excluded from the critical habitat designation.

4.5.3 Spatial and Temporal Distribution in Cook Inlet

The following discussion of the distribution of beluga whales in upper Cook Inlet is based upon many sources of information, including NMFS aerial surveys (see next paragraph); NMFS data from satellite-tagged belugas (Hobbs et al. 2005); opportunistic sightings; baseline studies of beluga whale occurrence in Knik Arm conducted for the Knik Arm Bridge and Toll Authority (KABATA) (Funk et al. 2005); baseline studies of beluga whale occurrence in Turnagain Arm conducted in preparation for Seward Highway improvements (Markowitz et al. 2007); marine mammal surveys conducted at Ladd Landing to assess a coal shipping project (Prevel-Ramos et al. 2008); marine mammal surveys off Granite Point, the Beluga River, and farther south in the inlet at North Ninilchik (Brueggeman et al. 2007, 2008a, 2008b); passive acoustic monitoring surveys throughout Cook Inlet (Lammers et al. 2013); JBER observations conducted within Eagle Bay and Eagle River (U.S. Army Garrison Fort Richardson 2009); and the scientific and construction monitoring program at the POA (Cornick and Pinney 2011, Cornick and Saxon-Kendall 2007, 2008; Cornick et al. 2010, Cornick et al. 2011; ICRC 2009a, 2010a, 2011a, 2012; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). These data have provided a relatively good picture of the distribution and occurrence of beluga whales in upper Cook Inlet, particularly in lower Knik Arm and the project area.

During the 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). Most beluga whale calving in Cook Inlet occurs from mid-May to mid-July in the vicinity of the river mouths, although Native hunters have described calving as early as April and as late as August (Huntington 2000).

NMFS Aerial Surveys

Since 1993, NMFS has conducted annual aerial surveys to document the distribution and abundance of beluga whales in Cook Inlet. In addition, to help establish beluga whale distribution in Cook Inlet throughout the year, aerial surveys were conducted every 1 to 2 months between June 2001 and June 2002 (Rugh et al. 2004a). These annual aerial surveys for beluga whales in Cook Inlet have provided systematic coverage of 13 to 33 percent of the entire inlet each year since 1994 including a 3-kilometer (1.9 mile)-wide strip along the shore and approximately 1,000 kilometers (621 miles) of off-shore transects (Hobbs et al. 2012; Rugh et al. 2000, 2005a, 2005b, 2006a, 2007; Shelden et al. 2012). Surveys designed to coincide with known seasonal feeding aggregations (Table 1.3 in Rugh et al. 2000) were generally conducted on 2 to 4 days per year in June or July at or near low tide in order to reduce the search area (Rugh et al. 2000). However, from June 2001 to June 2002, surveys were conducted during most months in an effort to assess seasonal variability in beluga whale distribution in Cook Inlet (Rugh et al. 2005a). Aerial surveys have also been conducted in August since 2005, with survey efforts focused on upper Cook Inlet (Rugh et al. 2005b, 2006a, Shelden et al. 2007, 2008, 2009, 2010, 2011; Sims et al. 2012). The average number of belugas sighted per day within Knik Arm ranged from 0 to 74 (**Table 4-4)**.

The collective survey results show that beluga whales are consistently found near or in river mouths along the northern shores of upper Cook Inlet (i.e., north of East and West Foreland). In particular, beluga whale groups are seen in the Susitna River Delta, Knik Arm, and along the shores of Chickaloon Bay. Small groups were recorded farther south in Kachemak Bay, Redoubt Bay (Big River), and Trading Bay (McArthur River) prior to 1996, but very rarely thereafter. Since the mid-1990s, most beluga whales (96 to 100 percent) have been concentrated in shallow areas near river mouths in upper Cook Inlet, and they are rarely sighted in the central or southern portions of Cook Inlet (Hobbs et al. 2008). Based on these aerial surveys, the concentration of beluga whales in the northernmost portion of Cook Inlet appears to be fairly consistent from June to October (Hobbs et al. 2011, 2012; Rugh et al. 2000, 2004a, 2005a, 2006a, 2007).

Table 4-4 Beluga whale observations in Knik Arm during NMFS annual aerial surveys

Year	Month	Average Number of Beluga Whales Sighted per Day	Range of Animals Observed per Day
2005	June	10	0–43
2005	August	74	64–85
2006	May	0	0
2006	June	1	0–9
2006	August	52	10–95
2007	June	14	0–27
2007	August	0	0
2008	August	45	25–61
2009	August	33	22–51
2010	August	48	27–73
2011	August	29	9–55
2012	August	17	11–27
2014	June	0	0

Source: Rugh et al. 2005a, 2005b, 2006a, 2006b, 2006c, 2007; Shelden et al. 2007, 2008, 2009, 2010, 2011, 2013, 2015; Sims et al. 2012.

Note: Average number of beluga whales sighted per day was rounded down, if applicable; averages may have included days when no belugas were observed but Knik Arm was surveyed.

NMFS Satellite Tag Study Results

In 1999, one beluga whale was tagged with a satellite transmitter, and its movements were recorded from June through September of that year. Since 1999, 18 beluga whales in upper Cook Inlet have been captured and fitted with satellite tags to provide information on their movements during late summer, fall, winter, and spring. Hobbs et al. (2005) described: (1) the recorded movements of two beluga whales (tagged in 2000) from September 2000 through January 2001; (2) the recorded movements of seven beluga whales (tagged in 2001) from August 2001 through March 2002; and (3) the recorded movements of eight beluga whales (tagged in 2002) from August 2002 through May 2003.

The concentration of beluga whales in the upper Cook Inlet appears to be fairly consistent from June to October based on aerial surveys (Rugh et al. 2000, 2004a, 2005a). Studies for KABATA in 2004 and 2005 confirmed the use of Knik Arm by beluga whales from July to October (Funk et al. 2005). Data from tagged whales (14 tags between July and March 2000 through 2003) show beluga whales 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 and Turnagain Arm and Chickaloon Bay as late as October, but some ranged into lower Cook Inlet to Chinitna Bay, Tuxedni Bay, and Trading Bay (McArthur River) in the fall (Hobbs et al. 2005, Goetz et al. 2012). In November, beluga whales moved between Knik Arm, Turnagain Arm, and Chickaloon Bay, similar to patterns observed in September (Hobbs et al. 2005, Goetz et al. 2012). By December, beluga whales were distributed throughout the upper to mid-inlet. From January into March, they moved as far south as Kalgin Island and slightly beyond in central offshore waters. Beluga whales also made occasional excursions into Knik Arm and Turnagain Arm in February and March in spite of ice cover greater than 90 percent (Hobbs et al. 2005). While 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).

Acoustic Monitoring in Cook Inlet

Passive acoustic monitoring of Cook Inlet beluga whales began in June of 2009 and continued through May 2010 with a deployment of 24 moorings throughout Cook Inlet. Moorings were located at 10 locations: North Eagle Bay, Eagle River, South Eagle Bay, Cairn Point, Fire Island, Beluga River, Trading Bay, Kenai River, Tuxedni Bay, and Homer Spit. Belugas were documented acoustically at all locations in upper Cook Inlet except for North Eagle Bay and South Eagle Bay (Lammers et al. 2013; **Table 4-5**).

Table 4-5 Summary of acoustic monitoring effort in Cook Inlet

Mooring Location	Number of Recording Dates	Mooring Depth (m)	Number of Beluga Whale Encounters	Number of Killer Whale Encounters
North Eagle Bay	17	13.7	0	0
Eagle River	47	10.0	11	0
South Eagle Bay	31	12.5	0	0
Cairn Point	185	28.3	3	0
Fire Island	295	23.5	5	0
Beluga River	246	18.0	53	1
Trading Bay	271	14.6	33	0
Kenai River	211	10.7	10	0
Tuxedni Bay	279	25.9	0	1
Homer Spit	271	18.6	0	15

Source: Lammers et al. 2013.

Seward Highway Study along Turnagain Arm

Markowitz et al. (2007) documented habitat use and behavior of beluga whales along the Seward Highway in Turnagain Arm from May through November 2006. This study was focused around the high tides when whales regularly traverse the near-shore channels to the mouths of rivers and streams, where they feed on fish. Most of the observations of whales occurred between the end of August and the end of October. No beluga whales were sighted in the study area in May, June, or July. The age composition of all whales observed was 58 percent adults, 17 percent sub-adults, 8 percent calves, and 17 percent unknown. Most beluga whale observations were in the upper Turnagain Arm, east of Bird

Creek. The observation station closest to the POA was at Potter Creek, but few beluga whales were sighted in the lower Turnagain Arm section of the project area. About 80 percent of all beluga whale sightings were within 1,100 meters (0.68 miles) off shore. About a third of all sightings in September were less than 50 meters (54.68 yards) from shore, while two-thirds of all sightings in October were within 50 meters (54.68 yards) off shore. Most beluga whale movements were with the tide: eastward into upper Turnagain Arm on the rising tide and westward out of Turnagain Arm on the falling tide. The few observations of beluga whales in lower Turnagain Arm were close to the mid-tide, indicating that beluga whales may use these areas closer to low tide rather than the high tide pattern observed in upper Turnagain Arm (Markowitz et al. 2007).

Marine Mammal Surveys at Ladd Landing

Prevel-Ramos et al. (2008) conducted surveys near Ladd Landing on the north side of upper Cook Inlet between Tyonek and the Beluga River from April through October 2006 and July through October 2007. The results from 2006 indicated that July through October had the least amount of beluga whale activity in the project area. Relatively few beluga whales were observed during the 2007 surveys near Ladd Landing, with three groups of 1 or 2 whales observed in July, two groups of 3 whales in September, and two groups averaging 7 whales in October. Two groups of 20 whales were observed near the Susitna Flats in August. Some of these whales may have been recorded more than once. Most of the whales sighted were close to shore. Of the whales seen in 2006 and 2007, 60 to 75 percent were white, 16 to 18 percent were gray, and the color of 10 to 22 percent was unknown.

Marine Mammal Surveys at Granite Point, Beluga River, and North Ninilchik

Brueggeman et al. (2007, 2008a, 2008b) conducted vessel and aerial surveys in 2007 near the Beluga River between 01 April and 15 May, Granite Point between 29 September and 21 October, and North Ninilchik between 25 October and 07 November. They recorded 148 to 162 beluga whales near the Beluga River with most observed during early May, 35 beluga whales near Granite Point with most observed in early to mid- October, and no beluga whales recorded off North Ninilchik. Most of the whales were observed near the shore. In addition, the movements indicated they were transiting through the areas to the head of the upper inlet. Small percentages of calves and yearlings were recorded with adults during the spring and early fall surveys. No beluga whales were observed at North Ninilchik, which is considered marginal habitat because of a lack of habitat structure (bays, inlets, etc.) combined with easy public access, typical of the eastern shore of the inlet.

JBER Eagle River Studies

The U.S. Army Garrison Fort Richardson has been interested in beluga whale presence within the Eagle River Flats since 1988 (U.S. Army Garrison Fort Richardson 2009). Information on monitoring effort in the 1980s and 1990s is limited; however, detailed records have been maintained since 2005. The U.S Army has been conducting beluga whale surveys since 2005 along Eagle River and Eagle Bay. Surveys were completed sometime between May and November annually, but always covered the months of June through October. Methodology was modified in 2008 to consist of group follow protocol and focal group sampling to provide increased statistical use of the data collected. Additionally in 2008, the U.S. Army deployed remote, color, motion-sensitive cameras to collected data on the presence or absence of beluga whales when observers could not be present. The highest numbers of sightings and numbers of beluga whales were documented in August and

September. Group sizes averaged 7.5 and13.6 individuals in 2007 and 2008, respectively. In August 2008, observed group size on multiple days was as large as 68 animals. Behaviors documented typically included traveling, milling, and diving, with occasional documentation of feeding or suspected feeding.

Opportunistic Sightings

Opportunistic sightings of beluga whales in Cook Inlet have been reported to NMFS since 1977. Beluga whale sighting reports are maintained in a database by NMML. Their high visibility and distinctive nature make them well-suited for opportunistic sightings along public access areas (e.g., the Seward Highway along Turnagain Arm, the public boat ramp at Ship Creek). Opportunistic sighting reports come from a variety of sources, including NMFS personnel conducting research in Cook Inlet, ADF&G, commercial fishermen, pilots, POA personnel, and the general public. Location data range from precise locations (e.g., Global Positioning System [GPS]-determined latitude and longitude) to approximate distances from major landmarks. In addition to location data, most reports include date, time, approximate number of whales, and notable whale behavior (Rugh et al. 2000, 2004a, 2005a). Since opportunistic data are collected any time, and often multiple times per week, these data often provide an approximation of beluga whale locations and movements in those areas frequented by natural resource agency personnel, fishermen, and others.

In 2007, the POA installed public signage at both the POA entrance and at the public boat ramp near the mouth of Ship Creek, which provides opportunistic reporting telephone numbers and reporting instructions. The POA trains POA operators, visitors, tenants, users, ship captains/pilots, and all maritime and construction personnel on how to properly document and report opportunistic sightings.

Depending upon the season, beluga whales can occur in both offshore and coastal waters. Although they remain in the general Cook Inlet area during the winter, they disperse throughout the upper and mid-inlet areas. Data from NMFS aerial surveys, opportunistic sighting reports, and satellite-tagged beluga whales confirm they are more widely dispersed throughout Cook Inlet during the winter months (November–April), with animals found between Kalgin Island and Point Possession (see **Figure 2-1**). Based upon monthly surveys (e.g., Rugh et al. 2000), opportunistic sightings, and satellite-tag data, there are generally fewer observations of these whales in the Anchorage and Knik Arm area from November through April (76 FR 20180; Rugh et al. 2004a).

4.5.4 Presence in Project Area

The POA conducted a NMFS-approved monitoring program for beluga whales and other marine mammals focused on the POA area from 2005 to 2011 as part of their permitting requirements for the MTRP (**Table 4-6**). Scientific monitoring was initiated in 2005 and was conducted by LGL Limited (LGL) in 2005 and 2006 (Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). Alaska Pacific University (APU) resumed scientific monitoring in 2007 (Cornick and Saxon-Kendall 2008) and continued monitoring each year through 2011. Additionally, construction monitoring occurred during in-water construction work.

Table 4-6 Summary of monitoring effort at POA

Year	Monitoring Effort	Time Frame	# of Days	# of Hours
2005	Scientific Monitoring (LGL)	August 2–November 28	51	374
2006	Scientific Monitoring (LGL)	April 26–November 3	95	564
2007	Scientific Monitoring (APU)	October 9–November 20	28	139
2008	Scientific Monitoring (APU)	June 24–November 14	86	612
2008	Construction Monitoring	July 24–November 26	108	607[a]
2009	Scientific Monitoring (APU)	May 4–November 18	86	783
2009	Construction Monitoring	March 28–December 14	231	3,322[a]
2010	Scientific Monitoring (APU)	June 29–November 19	87	600
2010	Construction Monitoring	July 21–November 20	106	862[a]
2011	Scientific Monitoring (APU)	June 28–November 15	104	1202
2011	Construction Monitoring	July 17–September 27	16	NA

[a] In-water pile-driving hours.

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

Notes: APU – Alaska Pacific University; LGL – LGL Limited; NA – Not Available.

Data on beluga whale sighting rates, grouping, behavior, and movement indicate that the POA is a relatively low-use area, occasionally visited by lone whales or small groups of whales. They are observed most often at low tide in the fall, peaking in late August to early September. Although groups with calves have been observed to enter the POA area, data do not suggest that the area is an important nursery area.

Although the POA scientific monitoring studies indicate that the area is not used frequently by many beluga whales, it is apparently used for foraging habitat by whales traveling between lower and upper Knik Arm, as individuals and groups of beluga whales have been observed passing through the area each year during monitoring efforts (**Table 4-7**). 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.

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 late August to mid-September. In all years, beluga whales have been observed to enter the project footprint while construction activities were taking place, including pile driving and dredging. The most commonly observed behaviors were traveling, diving, and suspected feeding. No apparent behavioral changes or reactions to in-water construction activities were observed by either the construction or scientific observers (Cornick et al. 2011).

Table 4-7 Beluga whales observed during POA monitoring effort

Year	Monitoring Effort	Total Number of Groups Sighted	Total Number of Beluga Whales	Monitoring Type
2005	August 2–Nov. 28	21	157	Scientific Monitoring
2006	April 26–Nov. 3	25	82	Scientific Monitoring
2007	October 9–Nov. 20	20	86	Scientific Monitoring
2008	June 2–Nov. 14	54	283	Scientific Monitoring
2008	July 24–Dec. 2	59	431	Construction Monitoring
2009	May 4–Nov. 18	54	166	Scientific Monitoring
2009	March 28–Dec. 14	NA	1,221	Construction Monitoring
2010	June 29–Nov. 19	42	115	Scientific Monitoring
2010	July 21–Nov. 20	103	731	Construction Monitoring
2011	June 28–Nov. 15	62	290	Scientific Monitoring
2011	July 17–Sept. 27	5	48	Construction Monitoring

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

Notes: NA - Not Available.

KABATA 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, 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. 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 the whales were using other portions of Cook Inlet. In addition, relatively few beluga whales were sighted in the spring and early to mid-summer months. Beluga whales predominantly frequented Eagle Bay (mouth of Eagle River), Eklutna, and the stretch of coastline in between, particularly when they were present in greater numbers (Funk et al. 2005).

Cook Inlet Beluga Whale Photo-ID Project

Beluga whales have persistent distinct natural markings that can be used to identify individual whales. 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 were surveyed annually from 2005–2013 (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 have traveled to the Eagle Bay area. These data provide evidence that most if not all of the population visits this area at least once in their lifetime. Groups containing calves or neonates are more likely to be seen in Knik Arm and Eagle Bay than other areas studied in upper Cook Inlet during the photo-id project (McGuire et al. 2011).

4.5.5 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). An audiogram for beluga whales from Nedwell et al. (2004) is provided in **Figure 4-8**.

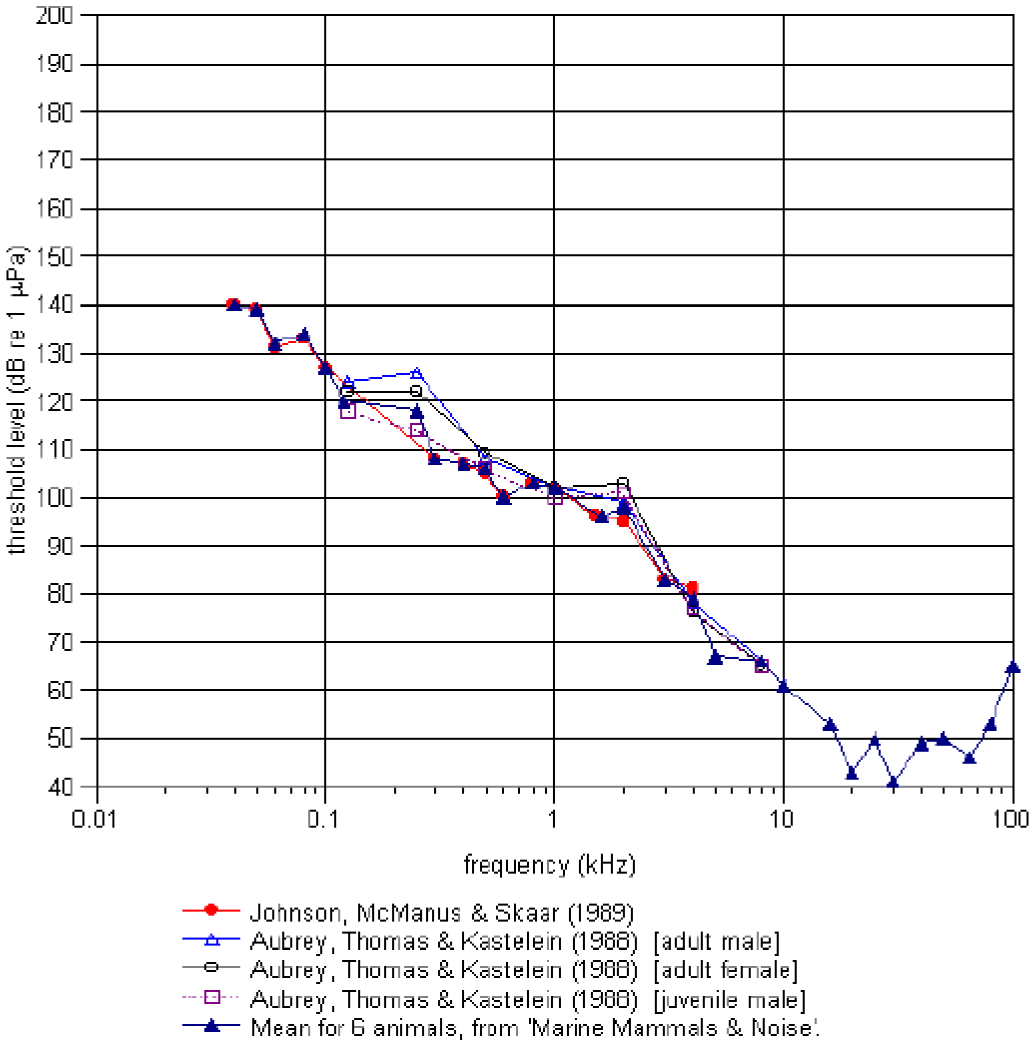

Figure 4-8 Beluga whale in-water audiogram (taken from Nedwell et al. 2004)

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SECTION 5.0

5 Type of Incidental Take Authorization Requested

5.1 Incidental Harassment Authorization

Under Section 101 (a)(5)(D) of the MMPA, the POA requests an IHA for the take of small numbers of marine mammals, by Level B behavioral harassment only, incidental to implementation of a Test Pile Program at the POA in Anchorage, Alaska. The POA requests an IHA for incidental take of marine mammals described within this application for 1 year commencing on 01 April 2016 (or the issuance date, whichever is later). The POA is not requesting an LOA at this time because the activities described herein are expected to be completed within 1 year from the date of authorization, and are not expected to rise to the level of injury or death, which would require an LOA.

5.2 Take Authorization Request

The POA requests an IHA from NMFS for Level B take (behavioral harassment) of small numbers of marine mammals described within this application as a result of in-water pile-driving activities. The POA requests that the IHA begins coverage on 01 April 2016.

The exposure assessment methodology used in this IHA application attempts to quantify potential noise exposures of marine mammals resulting from pile driving in the marine environment. **Section 6** presents a detailed description of the acoustic exposure assessment methodology. Results from this approach tend to provide an overestimation of 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 used idealized parameters, which are unrealistic in nature. Additionally, this approach assumes that all exposed individuals are "taken," contributing to an overestimation of "take."

The analysis for the Test Pile Program predicts 114 potential exposures (see **Section 6** for estimates of exposures by species) to impact and vibratory pile driving over the course of the project that could be classified as Level B harassment as defined under the MMPA. The purpose of the Test Pile Program is to gather design load information and acquire empirical data on noise levels produced during pile-driving operations in the waters of Knik Arm, and to use that knowledge to develop monitoring and mitigation methods to reduce impacts to marine mammals from future port modernization activities. The POA's mitigation measures for the Test Pile Program, described in **Section 11**, include monitoring of mitigation zones prior to the initiation of pile driving, the assessment of sound attenuation devices (e.g., encapsulated bubble curtains, resonance-based systems, and pile cushions) on impulsive and vibratory driven piles, and in-situ hydroacoustic recordings for assessment and comparisons of produced noise levels and sound attenuation. These mitigation measures decrease the likelihood that marine mammals will be exposed to sound pressure levels that would cause Level B harassment, although the amount of that decrease cannot be quantified.

The POA does not expect that 114 harassment incidents will result from the Test Pile Program. However, to allow for uncertainty regarding the exact mechanisms of the physical and behavioral effects, and as a conservative approach, the POA is requesting authorization for take (Level B harassment) of 114 marine mammals over the course of 1 year in this IHA application.

5.3 Method of Incidental Taking

Pile-driving activities associated with the Test Pile Program as outlined in **Section** 1 have the potential to disturb or displace small numbers of marine mammals. Specifically, the proposed activities may result in "take" in the form of Level B harassment (behavioral disturbance) only from underwater sounds generated from impact and vibratory pile driving. Level A harassment is not anticipated, given the methods of installation and measures designed to minimize the possibility of injury to marine mammals, including the use of soft start and shutdown procedures. See **Section 11** for more details on the impact reduction and mitigation measures proposed.

SECTION 6.0

6 Take Estimates for Marine Mammals

The NMFS application for IHAs requires applicants to determine the number of marine mammals that are expected to be incidentally harassed by an action and the nature of the harassment (Level A or Level B). Project construction activities as outlined in **Sections 1 and 2** have the potential to take marine mammals by harassment only, primarily through in-water pile driving. Other activities are not expected to result in take as defined under the MMPA. In-water pile driving will temporarily increase the local underwater and airborne noise environment in the vicinity of the POA area. Research suggests that increased noise may impact marine mammals in several ways and depends on many factors. This is discussed in more detail in **Section 7**. The following text provides a background on underwater sound, description of noise sources in the POA area; applicable noise criteria; a description of the methods used to calculate take; and the calculation of take.

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, while intensity describes the sound's loudness and is measured in decibels. Decibels are measured using a logarithmic scale.

The method commonly used to quantify airborne 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 the 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 hearing of marine mammals such as whales has not been developed for regulatory purposes. Therefore, sound levels underwater are not weighted and measure the entire frequency range of interest. In the case of marine construction work, the frequency range of interest is 10 to 10,000 Hz.

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 instantaneous peak SPL and the root-mean-square SPL (dB rms) during the pulse or over a defined averaging period. The peak sound pressure is the instantaneous maximum or minimum overpressure observed during each pulse or sound event and is presented in Pascals (Pa) or dB referenced to a pressure of one microPascal (dB re 1 μPa). The rms level is the square root of the energy divided by a defined time period. All sound levels throughout this report are presented in dB re 1 μPa.

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 microPascals (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 Hz to 20,000 Hz.
Peak Sound Pressure (unweighted), dB re 1 µPa	Peak sound pressure level is based on the largest absolute value of the instantaneous sound pressure over the frequency range from 20 Hz to 20,000 Hz. This pressure is expressed in this report as dB re 1 µPa.
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 sec	Proportionally equivalent to the time integral of the pressure squared in terms of dB re 1 μPa^2 sec over the duration of the impulse. Similar to the unweighted Sound Exposure Level standardized in airborne acoustics to study noise from single events.
Cumulative SEL	Measure of the total energy received through a pile-driving event (here defined as pile driving over 1 day).

Transmission loss (TL) underwater 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.

Spreading loss is typically 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 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 per doubling of distance.

6.2 Applicable Noise Criteria

NMFS recently published draft updated acoustic threshold levels that identify the received levels, or thresholds, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for all underwater anthropogenic sound sources (NOAA 2013). As these are still just draft guidelines, this application uses the currently applicable NMFS "do-not-exceed" criteria for exposure of marine mammals to various underwater sound sources, which are identified below and summarized in **Table 6-2**.

- **Level A Harassment: injury by impulse** (e.g., impact pile driving) **and continuous** (i.e., vibratory pile driving) **sounds**: NMFS has a "do-not-exceed" exposure criterion set at a sound pressure level (SPL) value of 180 dB referenced to 1 micropascal (dB re 1 µPa) root mean square (rms) for cetaceans and 190 dB re 1 µPa for pinnipeds.
- **Level B Harassment: harassment by impulse sounds**: (e.g., impact pile driving) is set at an SPL value of 160 dB re 1 µPa.
- **Level B Harassment: harassment by non-pulsed/continuous noise**: (e.g., vibratory pile driving) is set at an SPL value of 120 dB re 1 µPa rms.

Level A harassment is defined as "Any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined 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."

Table 6-2 Summary of underwater acoustic criteria for exposure of marine mammals to noise from continuous and pulsed sound sources

Species	Underwater Noise Thresholds (dB re 1µPa)			
	Vibratory Pile-Driving Disturbance Threshold	Impact Pile-Driving Disturbance Threshold	Injury Threshold	Frequency Range
Cetaceans	120 dB rms	160 dB rms	180 dB rms	7 Hz to 20 kHz (Low) 150 Hz to 20 kHz (Mid) 200 Hz to 20 kHz (High)
Pinnipeds	120 dB rms	160 dB rms	190 dB rms	75 Hz to 20 kHz

Although NMFS's current underwater acoustic criteria provide the framework for noise-impact assessment under the MMPA, to date, no research supports the contention that pinnipeds or odontocetes respond significantly to continuous sounds from vibratory pile driving as low as the 120-dB threshold. For example, Southall et al. (2007) reviewed studies that documented behavioral responses of harbor seals to continuous sounds under various conditions. They concluded that those studies, though limited, suggest that exposures between 90 dB and 140 dB re 1 µPa rms generally do not appear to elicit responses that result in significant changes to essential behaviors (e.g., foraging, resting, and migration).

6.3 Description of Noise Sources

For the purposes of this IHA application, the sound field in Knik Arm will be the existing ambient noise plus additional construction noise from the proposed Test Pile Program. 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, high winds, the seasonal presence of ice, and anthropogenic activities. Vessel activity, air traffic, construction noise (including dredging), and other anthropogenic sources are significant contributors to the ambient noise levels in Knik Arm.

Underwater sound levels in the POA area are comprised of multiple sources, including physical noise, biological noise, and anthropogenic (e.g., man-made) noise. Physical noise includes waves at the water surface, currents, earthquakes, moving sediments and silts, ice, and atmospheric noise. Biological noise includes sounds produced by marine mammals, fish, and invertebrates. Anthropogenic noise includes vessels (small and large), oil and gas operations, maintenance dredging, aircraft overflights, construction noise, and other sources, which produce varying noise levels and frequency ranges (**Table 6-3**).

Table 6-3 Representative noise levels of anthropogenic sources of sound commonly encountered in marine environments

Noise Source	Frequency Range (Hz)	Underwater Noise Level (dB rms re 1 μPa)	Reference
Small vessels	250–1000	151 dB at 1 m	Richardson et al. (1995)
Tug docking gravel barge	200–1,000	149 dB at 100 m	Blackwell and Greene (2002)
Container ship	100–500	180 dB at 1 m	Richardson et al. (1995)
Drilling platform	80	119 dB at 1.2 km	Blackwell and Greene (2002)
Dredging operations	50–3,000	120–140 dB at 500 m; 156.9 dB at 30 m	URS (2007); SFS (2009)
Aircraft overflights (underwater measurements)	Broadband; most energy > 2,000	110–134 dB	Blackwell and Greene (2002)
Impact driving of 36-inch piles at Port MacKenzie	100–1,500	206 dB (peak) at 62 m	Blackwell (2005)
Vibratory driving of 36-inch piles at Port MacKenzie	400–2,500	164 dB at 56 m[a]	Blackwell (2005)
Vibratory driving of 30-inch piles at POA	Centered at 6,000	131 dB at 35 m[a]	SFS (2009)

[a] Mean of measurements.

Notes: m – meters.

6.3.1 Pile Driving

The primary sound-generating activities associated with the proposed Test Pile Program will include vibratory installation followed by impact driving of steel shell piles (Illingworth & Rodkin 2014b). Vibratory pile driving produces continuous-type sounds, while impact pile driving produces pulsed-type sounds. Pulsed and continuous, non-pulsed sounds typically have differing potential to cause physical effects to marine mammals, particularly with regard to hearing. Pulsed sounds, such as impact driving, are typically isolated events, or are repeated in some succession. 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. Continuous or non-pulsed sounds, including machinery operations such as vibratory pile driving or drilling, are not characterized by large, rapid pressure fluctuations. For this reason, vibratory pile-driving activities do not typically result in physical injury to marine mammals; however, the duration and extent of such sounds can be greatly extended in highly reverberant environments (Southall et al. 2007).

Indicator piles 1 and 2 (**Figure 1-3**) will be cut off at or below the mudline immediately after being driven to their final depths. The exact method used to cut piles will be decided by the construction contractor, but several mechanical methods are common. Examples of mechanical methods include mechanical cutters, pneumatic saws, diamond wire cutters, abrasive jets, and hydraulic shears. These can be deployed by a crane or a deep sea diver. Noise associated with underwater pile cutting is expected to be similar to other machinery used for in-water construction. The noise impacts to marine mammals from pile cutting are expected to be negligible, especially when considered against the existing high ambient sound levels at the POA. Explosive or other non-mechanical methods will not be used without reinitiation of consultation. Use of mechanical methods for underwater pile cutting was not considered an important source of underwater noise for marine mammals during construction projects such as the Tappan Zee Bridge in New York (NMFS 2014), and will therefore not be considered further for the POA Test Pile Program.

6.3.2 Other Underwater Noise Sources

Tug Boats and Barges

Tug boats will be used in conjunction with barges to deliver materials to the project site as part of the Test Pile Program. Tug boats will follow well-established shipping lanes in Cook Inlet and Knik Arm, which are currently used by recreational and commercial vessels. When in operation, these 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 tug boats, 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 POA project area specifically, are frequently traversed by barges, tug boats, commercial vessels and tenders, and recreational vessels, and shipping lanes are frequently subject to dredging, an activity that produces underwater noise. These on-going uses and activities contribute to elevated background levels of noise in the project area. For example, in a 2001 acoustical study associated with construction at the POA, sound levels of 149 decibels were recorded from a tug pushing a barge (Blackwell and Greene 2002). 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 what levels of underwater sound exposure 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 (Jacobs and Terhune 2002; Costa et al. 2003; 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 and 140 dB rms, particularly those from 120 to 140 dB rms, ranged from no observable response whatsoever, 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 tug boats, 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 (LGL and Greeneridge 1986; Finley et al. 1990), documenting belugas' reactions to the approach and passage of ice-breaking ships in a remote area of Canada. These belugas were isolated stocks that were not accustomed to vessel traffic and associated noise, unlike Cook Inlet belugas. 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 (2008) 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 belugas 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 (2002) report that belugas 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-freight ship.

Observations of beluga whales off the POA suggest that belugas 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 that beluga whales must pass through in order to reach primary feeding areas to the north, where ambient underwater sound levels are significantly lower than the POA, suggesting a relationship between reduced sound levels and beluga use (Blackwell and Greene 2002). 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 2002). Overall, vessel-related sounds during this project are not expected to have more than a minor effect on the beluga whales in the project area.

Based on the reported in-water noise levels for a tug pulling a barge (145 to 166 dB rms), tugs will not produce sounds that exceed 180 or 190 dB rms at 1 m (3.3 feet) from the source. Therefore, they do not represent an acoustic injury concern for marine mammals, and no Level A take will occur.

Geotechnical Investigations

Limited data exist regarding underwater noise levels associated with SPT or CPT investigations, and no data exist for SPT or CPT geotechnical investigations in Cook Inlet or Knik Arm. Hydroacoustic tests conducted by Illingworth & Rodkin (2014a) in May 2013 revealed that underwater noise levels from large drilling operations and rig generators were below ambient noise levels. On two different occasions, Sound Source Verification (SSV) measurements were made of conductor pipe drilling, with and without other noise-generating activities occurring simultaneously. Drilling sounds could not be measured or heard above the other sounds emanating from the rig. The highest sound levels measured that were emanating from the rig during drilling were 128 dB rms, and they were attributed to a different sound source (Illingworth & Rodkin 2014a). Geotechnical drilling for the POA, which includes SPT or CPT sampling, will be of smaller size and scale than the full-scale drilling operation studied here and of little concern regarding harassment of marine mammals.

Similar to vessel operations, on-going use of the POA by commercial and recreational vessels contributes to the underwater noise baseline. Elevated, chronic sound levels associated with POA activities likely mask additional sound sources at those same or lesser values. It is anticipated that noises associated with geotechnical investigations will be masked by background noise since the marine mammals that transit through this area are routinely exposed to sounds louder than 120 dB rms, and continue to use this area. Continued use of the area suggests that they are not harassed by underwater sounds that exceed the continuous disturbance threshold.

6.4 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 a second to a year (Richardson et al. 1995). Background noise levels at the POA site are known to be variable over time due to a number of biological, physical, and anthropogenic sources. Background sound levels have been measured at the POA in the past as part of an underwater survey conducted for the POA in 2007 (URS 2007). The ambient background SPLs obtained in that study were highly variable, ranging from 105 to 135 dB re 1 μPa. The lowest background SPLs were measured during periods when the recording vessel outboard motors were off and far from any visible noise sources (105 to 120 dB re 1 μPa). The highest background SPLs were measured when the tugs were pulling barges (135 dB re 1 μPa at 200 m).

Other sources of noise in the POA area consisted of dredging operations, boats, ships, and aircraft overflights from JBER, all of which contribute to the high noise levels in upper Cook Inlet (e.g., Blackwell and Greene 2002; KABATA 2011). Measured SPLs associated with dredging operations ranged from 120 to 140 dB at 550 meters (602 yards). During periods of strong currents, water flow and strumming caused noise levels in excess of 135 dB. These levels are consistent with other measurements conducted in Cook Inlet by Blackwell (2005). In the LOA that was issued to the POA for 2009–2014, the 125 dB re 1 μPa rms threshold for vibratory pile driving was used instead of the 120 dB re 1 μPa rms threshold, due to the high background noise levels measured in Knik Arm (e.g., Blackwell 2005; URS 2007). Based on these past studies and assessments, the background or ambient noise levels in the vicinity of the Test Pile Program were assumed to be 125 dB rms for this IHA application. Furthermore, use of 125 dB rms ambient noise levels was approved for this project in a letter from NMFS dated 17 November 2015 (NMFS 2015).

6.5 Distances to Sound Thresholds and Areas

Pile driving will generate underwater noise that potentially could result in disturbance to marine mammals, if present in the project area. Sound from pile installation (i.e., vibratory or impact driving) will transmit or propagate to the surrounding waters from each pile-driving location.

Illingworth & Rodkin (2014b) estimated underwater sound levels from pile-driving activities for the POA and the Test Pile Program by using the results of measurements that were previously performed for similar projects in different areas, including the review of available underwater sound data for projects involving the installation of similar types of piles (**Table 6-4**; Illingworth & Rodkin 2012, 2013). The sound levels for proposed pile-driving activities were estimated by using these data combined with an understanding of how and where these activities will occur during the Test Pile Program. The resulting predictions are essentially a best estimate based on empirical data and engineering judgment, and by their very nature contain a degree of uncertainty. The duration of driving for each pile installation and number of pile strikes were also estimated as part of the noise prediction process, based on available data from similar projects and engineering estimates of the geotechnical features at the Test Pile Program site.

Table 6-4 Underwater sound levels at 10 meters based on measurements at U.S. Navy Kitsap Bangor Naval Base

Pile-Driving Scenario	Peak Pressure (dB re 1μPa)	rms Sound Pressure Level (dB re 1μPa)	SEL (dB re 1μPa^{2}sec)	Propagation Rate X * Log (dist./10m)
48-inch-diameter Vibratory Installation	<200 dB	164 dB	--	15
48-inch-diameter Impact Pile Driving	209 dB	192 dB	180 dB	15

Source: cited in Illingworth & Rodkin 2014b.
Original Sources: Illingworth & Rodkin 2012, 2013.

NMFS uses a practical spreading model to predict sound levels at various distances from the source, and to predict the distances at which injury and harassment thresholds will be reached. The formula for transmission loss is TL = X log10 (R/10), where R is the distance from the source assuming the near source levels are measured at 10 meters (33 feet) and X is the practical spreading loss value. In the absence of reliable data, NMFS typically recommends a default practical spreading loss of 15 dB per tenfold increase in distance. In accordance with direction from NMFS specific to this project (NMFS 2015), the practical spreading loss model that uses 15log(R) will be used to calculate TL. This TL model, based on the default practical spreading loss assumption, was used to predict underwater sound levels generated by pile installation for this project (**Table 6-5**). Pile-driving sound measurements recorded during the Test Pile Program will further refine the rate of sound propagation or TL in the vicinity of the POA.

Table 6-5 Distances to NMFS' Level A injury and Level B harassment thresholds (isopleths) for a 48-inch-diameter pile, assuming a 125-dB background noise level and log 15 as the transmission loss value

Pile diameter (inches)	Impact			Vibratory		
	Pinniped, Level A Injury	Cetacean, Level A Injury	Level B Harassment	Pinniped, Level A Injury	Cetacean, Level A Injury	Level B Harassment
	190 dB	180 dB	160 dB	190 dB	180 dB	125 dB
48, unattenuated	14 m	63 m	1,359 m	<10 m	<10 m	3,981 m

- The distances to the Level B harassment and Level A injury isopleths were used to estimate the areas of the Level B harassment and Level A injury zones for an unattenuated 48-inch pile (**Table 6-6**; **Figures 6-1 – 6-6**). Distances and areas were calculated for both vibratory and impact pile driving, and for cetaceans and pinnipeds. Geographic information system software was used to map the Level B harassment and Level A injury isopleths from each of the six indicator test pile locations (**Figure 1-3**). Land masses near the POA, including Cairn Point, the North Extension, and Port MacKenzie, act as barriers to underwater noise and prevent further spread of sound pressure waves. As such, the harassment zones for each threshold were truncated and modified with consideration of these impediments to sound transmission (**Figures 6-1 – 6-6**). The measured areas (**Table 6-6**) were then used in take calculations for beluga whales (see **Section 6.6.2**). Although sound attenuation methods will be used during pile installation, it is unknown how effective they will be and for how many hours they will be utilized. Therefore, to estimate potential exposure of beluga whales, the areas of the harassment zones for impact and vibratory pile driving with no sound attenuation were used.

Table 6-6 Areas of the Level A injury zones and Level B harassment zones[a]

<table>
<tr><th rowspan="3">Indicator Pile Tests</th><th colspan="3">Impact</th><th colspan="3">Vibratory</th></tr>
<tr><th>Pinniped, Level A Injury</th><th>Cetacean, Level A Injury</th><th>Level B Harassment</th><th>Pinniped, Level A Injury</th><th>Cetacean, Level A Injury</th><th>Level B Harassment</th></tr>
<tr><th>190 dB</th><th>180 dB</th><th>160 dB</th><th>190 dB</th><th>180 dB</th><th>125 dB</th></tr>
<tr><td>Piles 3 and 4</td><td rowspan="6"><0.01 km^2</td><td rowspan="6">0.01 km^2</td><td>2.24 km^2</td><td rowspan="6">0</td><td rowspan="6">0</td><td>15.54 km^2</td></tr>
<tr><td>Pile 1</td><td>2.71 km^2</td><td>19.54 km^2</td></tr>
<tr><td>Pile 2</td><td>2.76 km^2</td><td>20.08 km^2</td></tr>
<tr><td>Piles 5 and 6</td><td>2.79 km^2</td><td>20.90 km^2</td></tr>
<tr><td>Pile 7</td><td>2.80 km^2</td><td>20.95 km^2</td></tr>
<tr><td>Piles 8, 9, and 10</td><td>3.03 km^2</td><td>22.14 km^2</td></tr>
</table>

[a] Based on the distances to sound isopleths in **Table 6-5** for a 48-inch-diameter pile, assuming a 125-dB background noise level.

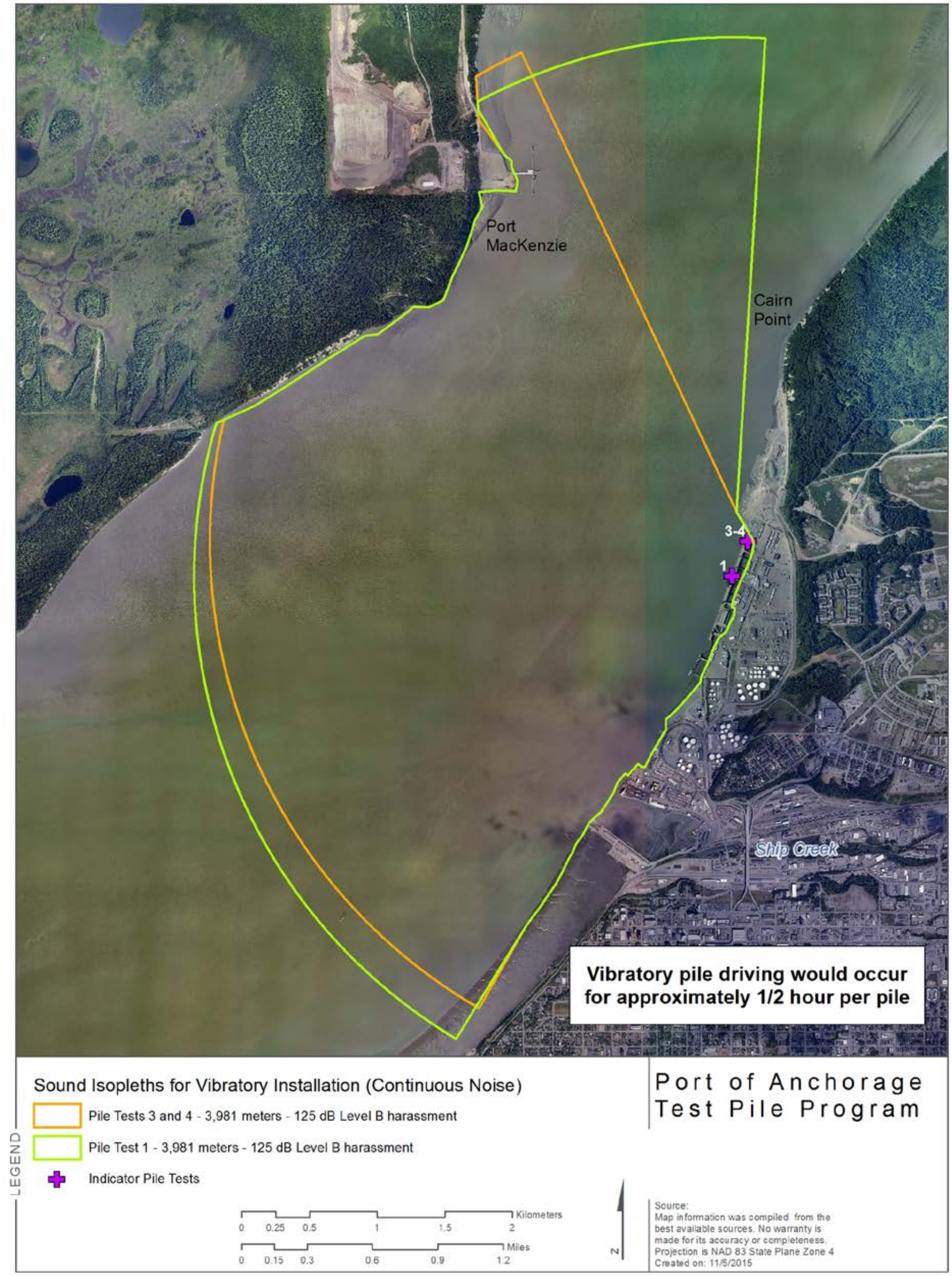

Figure 6-1 Distances to the sound isopleths for vibratory installation at indicator pile tests 1, 3, and 4

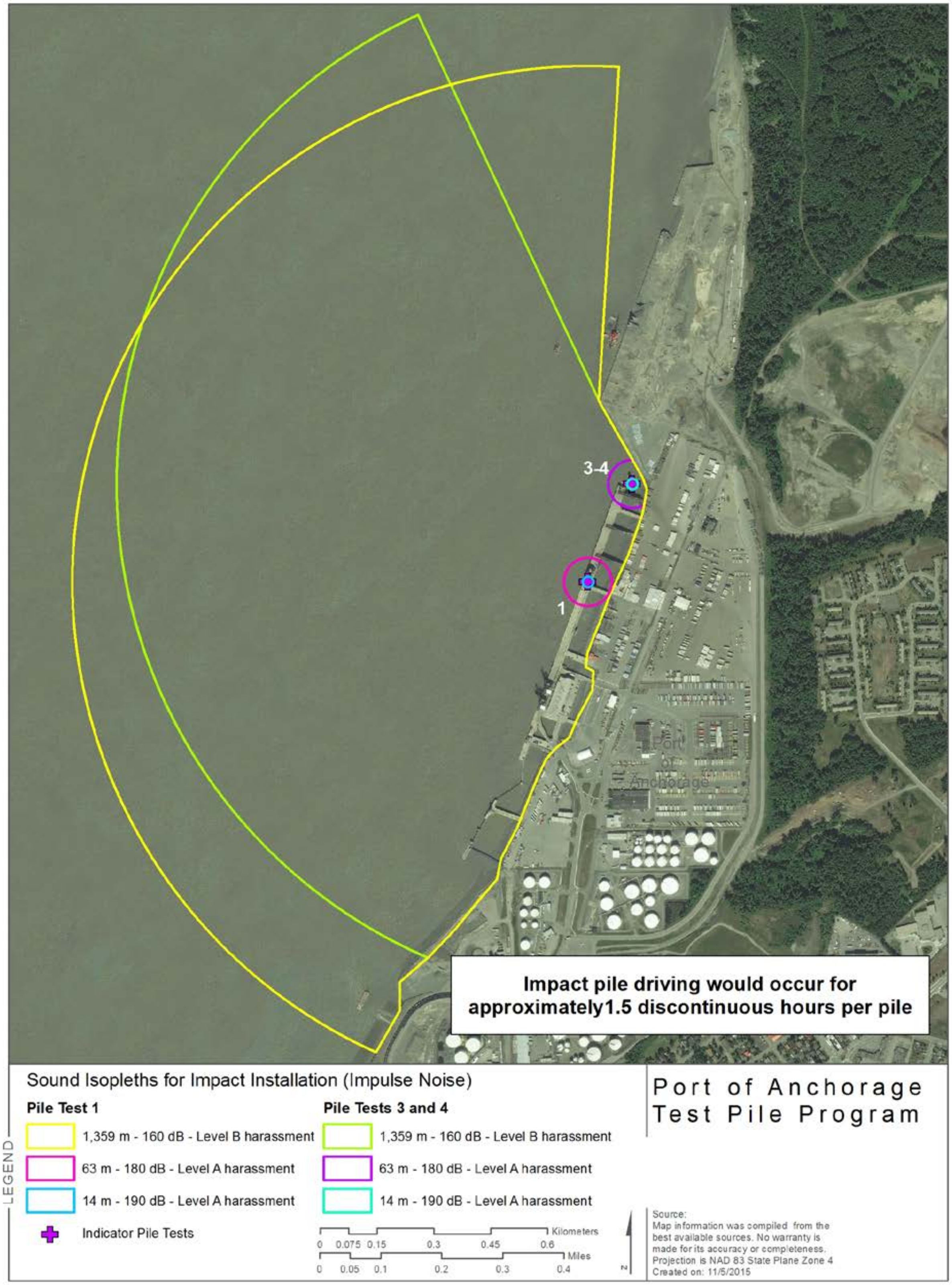

Figure 6-2 Distances to the sound isopleths for impact installation at indicator pile tests 1, 3, and 4

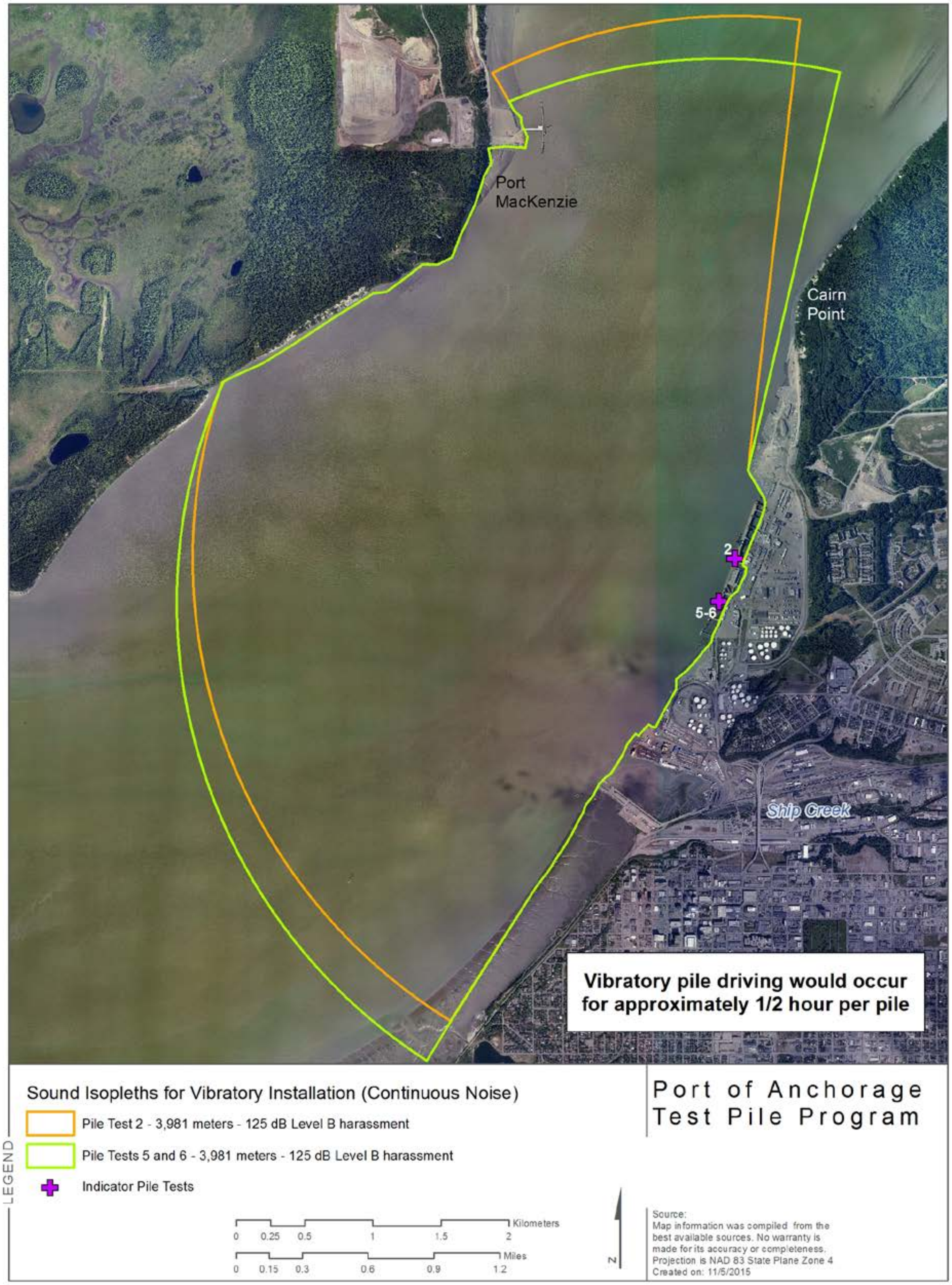

Figure 6-3 Distances to the sound isopleths for vibratory installation at indicator pile tests 2, 5, and 6

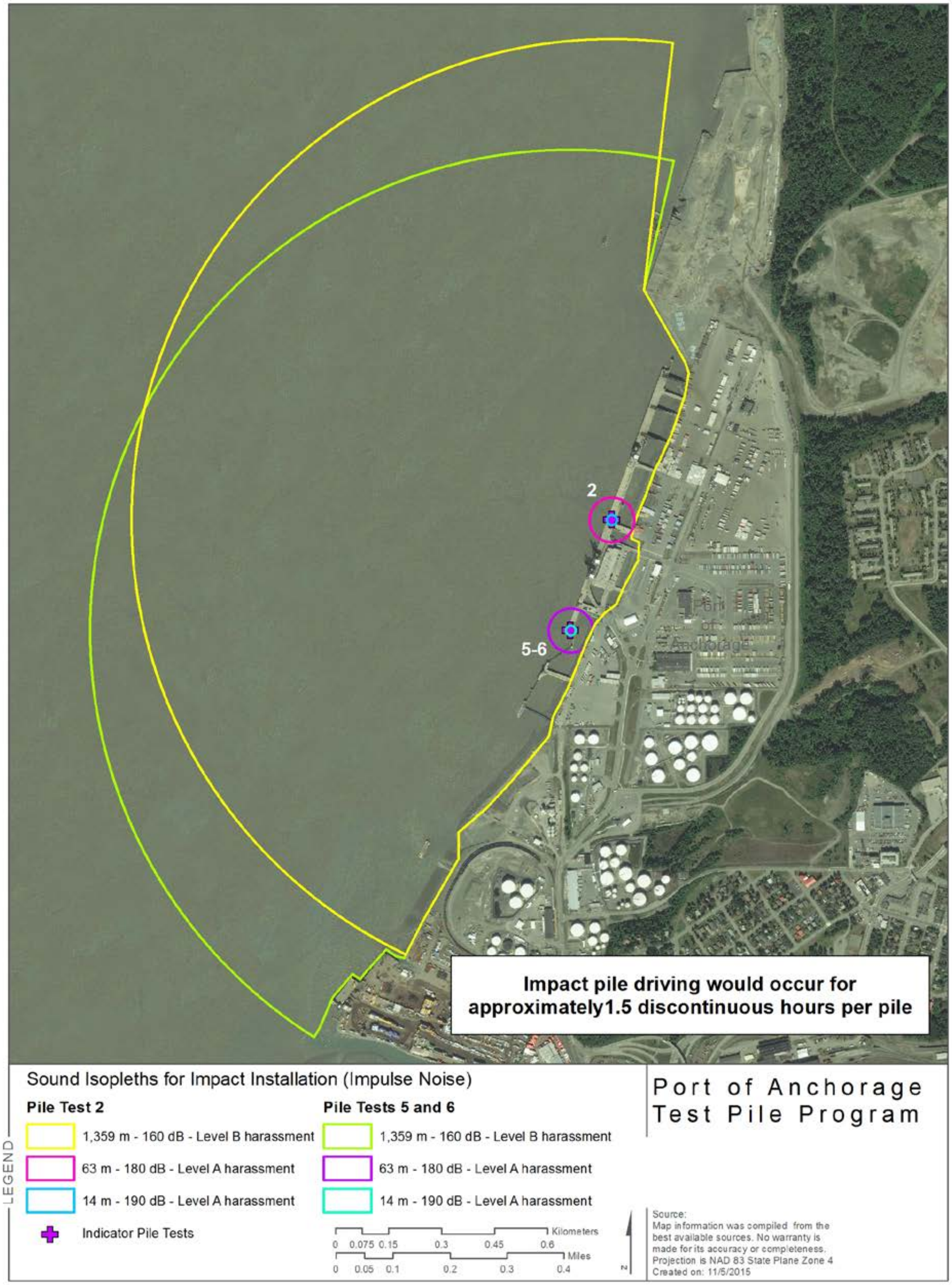

Figure 6-4 Distances to the sound isopleths for impact installation at indicator pile tests 2, 5, and 6

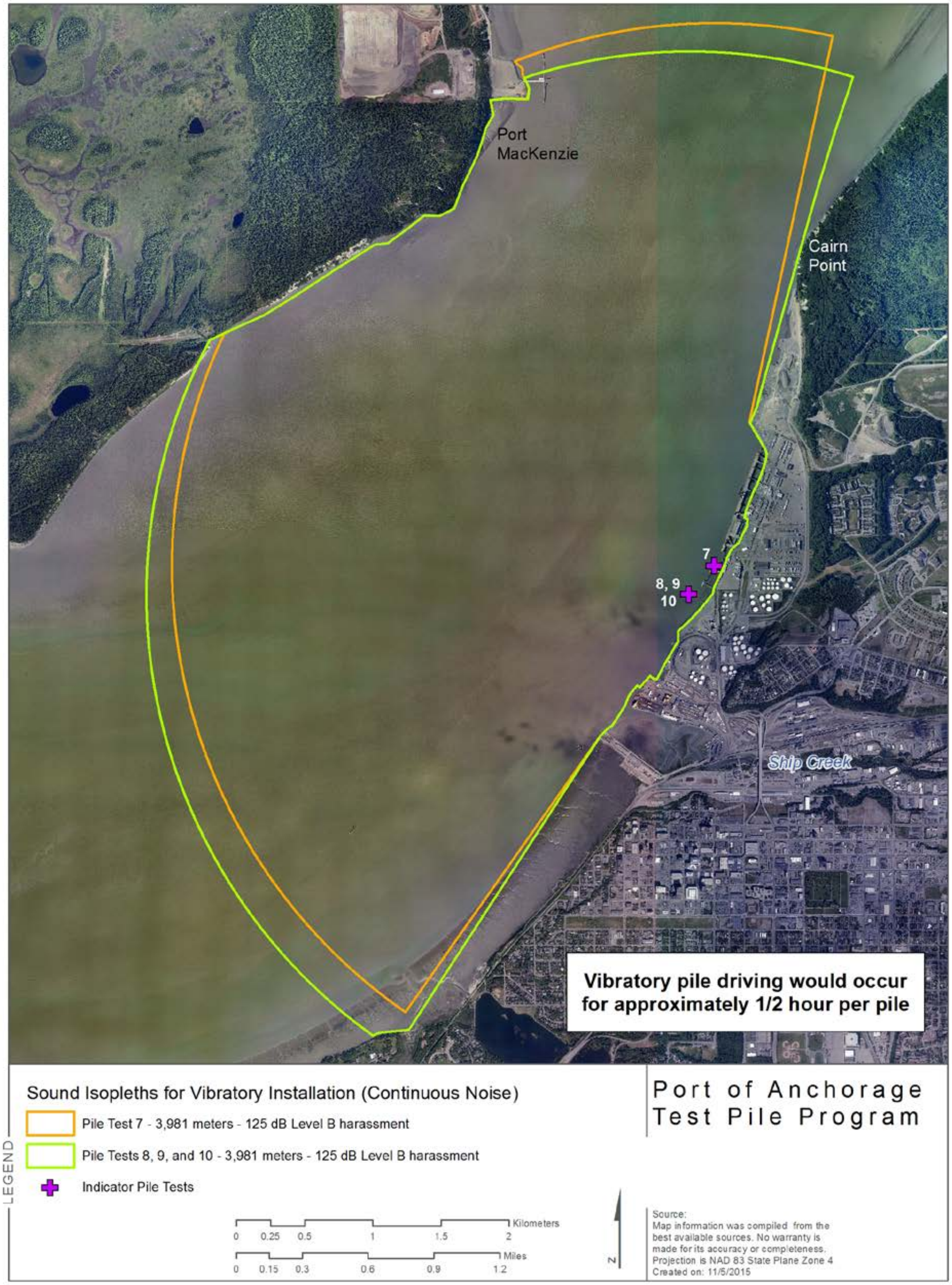

Figure 6-5 Distances to the sound isopleths for vibratory installation at indicator pile tests 7, 8, 9, and 10

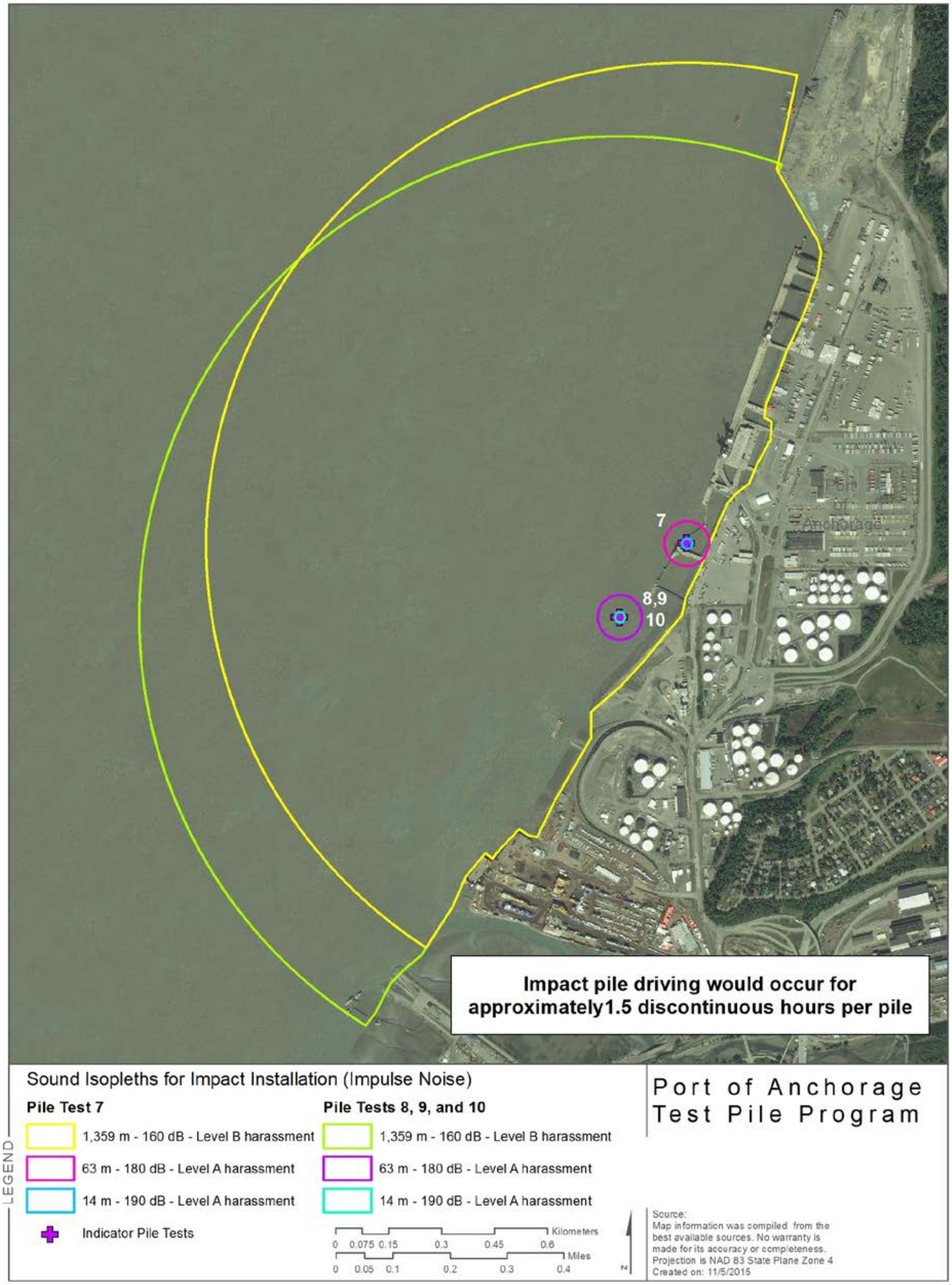

Figure 6-6 Distances to the sound isopleths for impact installation at indicator pile tests 7, 8, 9, and 10

6.6 Description of Take Calculation Methodology

6.6.1 Other Marine Mammals

Monitoring data recorded for the MTRP were used to estimate daily sighting rates for harbor seals and harbor porpoises in the project area (**Table 4-1**, **Table 4-2**). Sighting rates of harbor seals and harbor porpoises were highly variable, and there was some indication that reported sighting rates may have increased during the years of MTRP monitoring (**Table 4-1**, **Table 4-2**). It is unknown whether any increase, if real, were due to local population increases or habituation to on-going construction activities. Shelden et al. (2014) reported evidence of increased abundance of harbor porpoise in upper Cook Inlet, which may have contributed to this pattern. As a conservative measure, the highest monthly individual sighting rate for any recorded year was used to quantify take of harbor seals and harbor porpoises for pile driving associated with the Test Pile Program.

The pile driving take calculation for all harbor seal and harbor porpoise exposures is:

Exposure estimate = N * # days of pile driving per site, where:

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

Take for Steller sea lions was estimated based on three sightings of what was likely a single individual. Take for killer whales was estimated based on their known occasional presence in the project area, even though no killer whales were observed during past MTRP monitoring efforts.

6.6.2 Beluga Whales

Aerial surveys for beluga whales in Cook Inlet were completed in June and July from 1993 through 2008 (Goetz et al. 2012). 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. 2012). 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. Second, the expected group size was mapped. Group size followed a Poisson distribution, which ranged from 1 to 232 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. (2012) developed a raster GIS dataset which provides a predicted density of beluga whales throughout Cook Inlet at a scale of one square kilometer (**Figure 6-7**). Habitat maps for beluga whale presence, group size, and density (beluga whales/km^2) were produced from these data and resulting model, including a raster Geographic Information System data set, which provides a predicted density of beluga whales throughout Cook Inlet at a 1-km^2-scale grid (**Figure 6-7**).

The numbers of beluga whales potentially exposed to noise levels above the Level B harassment thresholds for impact (160 dB) and vibratory (125 dB) pile driving were estimated using the following formula:

Beluga Exposure Estimate = N * Area * number of days of pile driving (Table 1-2), where:

N = maximum predicted # of beluga whales/km^2

Area = Area of Isopleth (area in km^2 within the 160-dB isopleth for impact pile driving, or area in km^2 within the 125-dB isopleth for vibratory pile driving; see **Table 6-6**)

The beluga whale exposure estimate was calculated for each of the six indicator test pile locations (**Figure 1-3**) separately, because the area of each isopleth was different for each location. The predicted beluga whale density raster (developed by Goetz et al. 2012) was overlaid with the isopleth areas (**Figures 6-1 – 6-6**) for each of the indicator test pile locations. The maximum predicted beluga whale density within each area of isopleth was then used to calculate the beluga whale exposure estimate for each of the indicator test pile locations. The maximum density values ranged from 0.031 to 0.063 beluga whale/km^2 (**Table 6-7**).

The area values from **Table 6-6** were multiplied by the maximum predicted densities shown in the two left columns in **Table 6-7**. The final step in the equation is to account for the number of days of exposure. As discussed in **Section 1.2**, the maximum number of days of impact pile driving, plus a 25 percent contingency, is 31 days (**Table 1-2**). As such, the predicted exposure estimate for each of the 10 indicator test piles was multiplied by 3.1 to account for the number of days of exposure. The maximum number of days of vibratory pile driving (10), plus a 25 percent contingency, is 12.5 days. As such, the predicted exposure estimate for each indicator test pile was multiplied by 1.25 to account for the number of days of exposure. The total estimated exposure of beluga whales to Level B harassment from impact pile driving (160 dB) is 3.884, or 4 individuals. The total estimated exposure of beluga whales to Level B harassment from vibratory pile driving (125 dB) is 15.361, or 16 individuals. The expected number of beluga whale exposures for each indicator test pile and total exposure estimates is shown in **Table 6-7**.

Table 6-7 Maximum predicted beluga whale densities and exposure estimates within each of the six unique isopleth areas

Indicator Test Pile(s)	Impact Pile Driving (160 dB) Maximum Density (beluga whales/km^2)	Vibratory Pile Driving (125 dB) Maximum Density (beluga whales/km^2)	Impact Pile Driving (160 dB) Exposure Estimate	Vibratory Pile Driving (125 dB) Exposure Estimate
Piles 3 and 4	0.031	0.056	0.428	2.191
Pile 1	0.042	0.063	0.350	1.541
Pile 2	0.038	0.062	0.329	1.550
Piles 5 and 6	0.062	0.062	1.066	3.225
Pile 7	0.062	0.062	0.536	1.617
Piles 8, 9, and 10	0.042	0.063	1.175	5.238
		Total Exposure Estimates	**3.884 (4)**	**15.361 (16)**

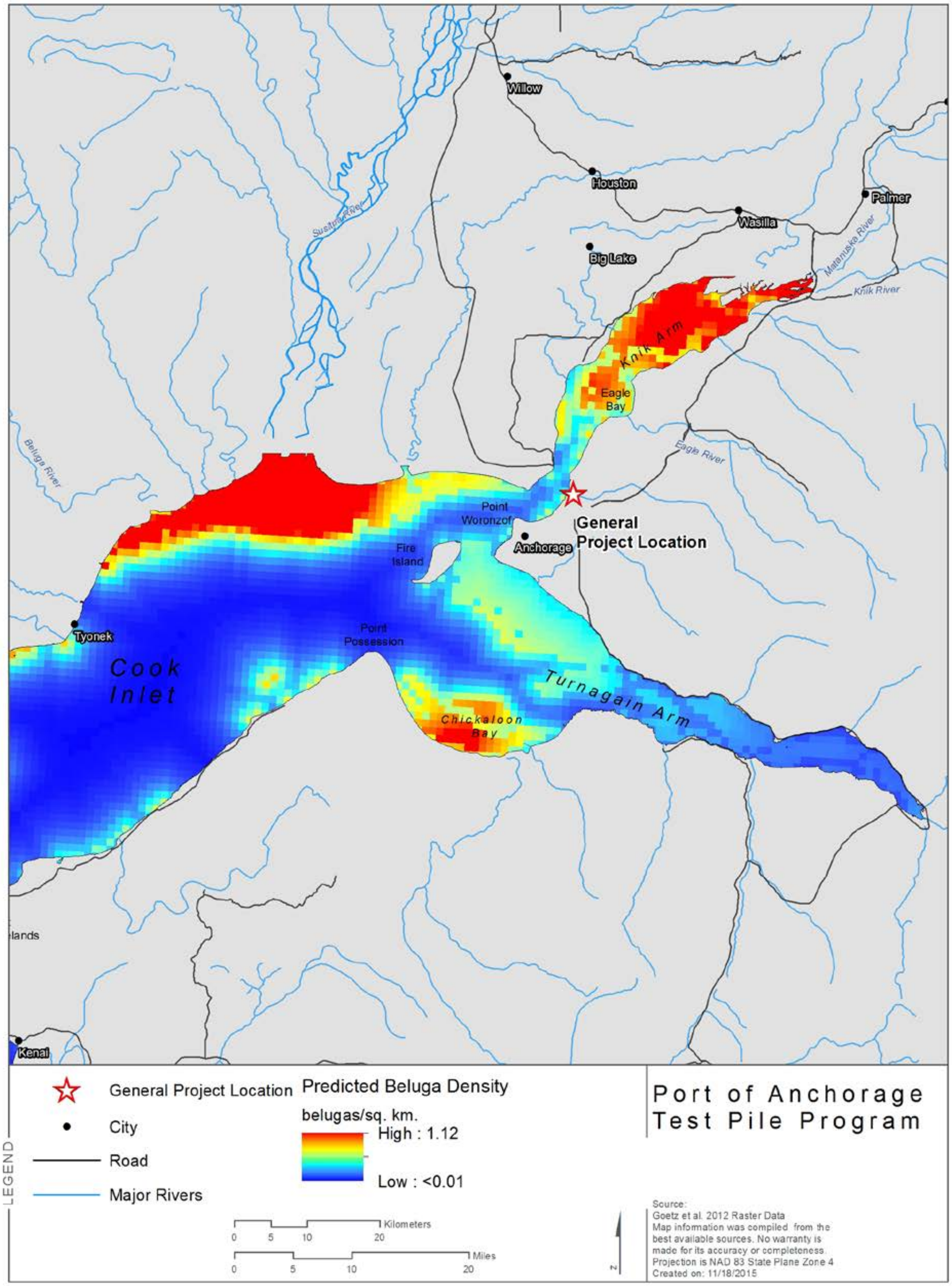

Figure 6-7 Predicted beluga whale densities within upper Cook Inlet based on Goetz et al. 2012 geospatial data

6.7 Estimated Numbers Exposed to Noise

6.7.1 Harbor Seals

No known harbor seal haul-out or pupping sites occur in the vicinity of the POA; therefore, airborne noise is not considered in this application. With the exception of newborn pups, all ages and sexes of harbor seals could occur in the project area for the duration of the Test Pile Program. However, harbor seals are not known to regularly reside in the POA area. For these reasons, any harassment to harbor seals during test pile driving will primarily involve a limited number of individuals that may potentially swim through the project area. Harbor seals that are disturbed by noise may change their behavior and be temporarily displaced from the project area for the short duration of test pile driving.

The maximum number of harbor seals observed during POA construction monitoring conducted from 2005 through 2011 was 57 individuals, recorded over 104 days of monitoring, from 28 June–15 November 2011 (**Table 4-1**). Based on these observations, sighting rates during the 2011 POA construction monitoring period were 0.55 harbor seal/day. Take by Level B harassment during 31 days of impact and vibratory pile driving for the Test Pile Program is anticipated to be less than 1 harbor seal per day, but we have rounded this rate to 1 harbor seal/day to be conservative. With in-water pile driving occurring for only about 27 hours over those 31 days, the potential for exposure within the 160-dB and 125-dB isopleths is anticipated to be low. Level B take is conservatively estimated at a total of 31 harbor seals (31 days x 1 harbor seal/day) for the duration of the Test Pile Program. Few harbor seals are expected to approach the project area, and this small number of takes is expected to have no more than a negligible effect on individual animals, and no effect on the population as a whole. Level B harassment has the most potential to occur during the mid-summer and fall when anadromous prey fish return to Knik Arm, in particular near Ship Creek south of the POA area. Because the unattenuated 190-dB isopleth is estimated to extend only 13 meters from the source, no Level A take is anticipated, nor requested under this authorization.

6.7.2 Steller Sea Lions

Steller sea lions are expected to be encountered in low numbers, if at all, within the project area (see **Section 4.4**). However, based on the three sightings of what was likely a single individual in the project area in 2009, the POA requests the take of up to 6 individuals over the duration of test pile driving activities. The proposed Test Pile Program will drive piles for approximately 31 days, and therefore, the proposed encounter rate of Steller sea lions is 1 individual about every 5 pile driving days. Because the unattenuated 190-dB isopleth is estimated to extend only 13 meters from the source, no Level A take is anticipated, nor requested under this authorization.

6.7.3 Harbor Porpoises

Aerial surveys designed specifically to estimate population size for the three management stocks of harbor porpoises in Alaska were conducted in 1997, 1998, and 1999 (Hobbs and Waite 2010). As part of the overall effort, Cook Inlet harbor porpoises were surveyed 9–15 June 1998 by NMFS as part of their annual beluga whale survey effort (Hobbs and Waite 2010; Rugh et al. 2000). The survey yielded an average harbor porpoise density in Cook Inlet of 0.013 harbor porpoise/km^2, with a coefficient of variation of 13.2 percent. Although the survey transited both upper and lower Cook Inlet, harbor porpoise sightings were limited to 8, 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 summer timing of this survey effort and lack of upper Cook Inlet sightings, the POA has determined that use of this density for estimating take of harbor porpoises in association with the Test Pile Program, which is planned for the fall season, will not be appropriate.

Harbor porpoise sighting rates during the POA pre-construction monitoring period in 2007 were rare, and only four sightings were reported in 2005 (**Table 4-2**). Harbor porpoise sighting rates in the project area from 2008–2011 during pile driving and other port activities ranged from 0–0.09 harbor porpoise/day. We have rounded this up to 1 harbor porpoise per day. Take by Level B harassment during the Test Pile Program over 31 days of pile driving activity is estimated to be no more than 31 harbor porpoises (31 days x 1 harbor porpoise/day). Harbor porpoises sometimes travel in small groups, so as a contingency, an additional 6 harbor porpoise takes are estimated, for a total of 37 Level B takes. With in-water pile driving occurring for only about 27 hours over those 31 days, the potential for exposure within the 160-dB and 125-dB isopleths is anticipated to be low. Few harbor porpoises are expected to approach the project area, and this small number of takes is expected to have no more than a negligible effect on individual animals and no effect on the population as a whole. Because the unattenuated 190-dB isopleth is estimated to extend only 51 meters from the source, no Level A take is anticipated, nor requested under this authorization.

6.7.4 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, based on a review of monitoring reports. 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). If present during pile driving, killer whales may change their behavior and be temporarily displaced from the area for a short period of time.

With in-water pile driving occurring for only about 27 hours over 31 days (with the 25 percent schedule contingency), the potential for exposure within the Level B harassment isopleths is anticipated to be extremely low. Level B take is conservatively estimated at no more than 8 killer whales, or two small pods, for the duration of the Test Pile Program. Few killer whales are expected to approach the project area, and this small potential exposure is expected to have no more than a negligible effect on the individual animal and no effect on killer whale populations as a whole. Because the unattenuated 190-dB isopleth is estimated to extend only 51 meters from the source, no Level A take is anticipated or requested under this authorization.

6.7.5 Beluga Whales

Based on predicted beluga whale density in the vicinity of the POA, an estimated total of 20 beluga whales could be exposed to noise levels at the Level B harassment level during vibratory and impact pile driving (**Table 6-8**). Estimated exposures are rounded up to the nearest integer (whole animal) for each method of pile installation.

Table 6-8 Estimated numbers of beluga whales potentially exposed to Level B harassment noise from pile driving in 2016

Month	Days of Pile Driving			Estimated Number of Beluga Whales in Area		Numbers of Individuals Potentially Exposed[a]
	Vibratory	Impact	Total	Vibratory	Impact	
April - July	10	21	31	16	4	20

[a] Numbers of individuals are rounded up to integers.

Note that the schedule assumes MMPA authorization by April 2016. If authorization is delayed, the schedule will be delayed accordingly, pending authorization under the MMPA. Therefore, pile driving may occur during the month following authorization.

It is important to note that the Goetz et al. (2012) dataset creates an estimated density distribution that both moderates and redistributes actual beluga densities. Beluga whale distribution in Cook Inlet is much more clumped than is portrayed by the estimated density model (**Figure 6-7**). Furthermore, these data represent a snap-shot in time. 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. Although beluga whales may occasionally linger in the vicinity of the POA, they typically transit through the area. It is important to note that the instantaneous probability of observing a beluga whale at any given time is extremely low (0.0 to 0.01) based on the Goetz et al. (2012) 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. (2012) density model is the best available information for upper Cook Inlet and for the estimation of beluga whale density across large areas. However, in order to account for the clumped and highly variable distribution of beluga whales, we have accounted for large groups to improve our estimate of exposure.

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, groups of beluga whales were occasionally taken by Level B harassment during previous POA activities (**Table 6-9**). Beluga whales were reported as take when animals entered the harassment zone during vibratory driving activities. On the only occasion when impact pile driving was taking place when beluga whales were taken, vibratory pile driving was also taking place (**Table 6-9**). The animals did not appear to avoid areas ensonified to the 120-dB level during the continuous sound of vibratory pile driving, and willingly swam into the Level B harassment zone. No changes in behavior were detected.

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 project site near the shore when they surfaced in the Level B harassment zone during vibratory pile driving (ICRC 2009b). Construction activities were immediately shut down, but the 15 whales were documented as takes. On other occasions, beluga whales were initially sighted outside of the harassment zone and shut down was called, but the beluga whales swam into the harassment zone before activities 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 construction activity could be shut down, and was documented as a take (ICRC 2009c).

The POA intends to implement a rigorous monitoring and mitigation program during all pile driving activity, including shutting down for groups of more than five beluga whales that appear to be heading for the Level B harassment zone, in an effort to minimize take and reduce impacts to the animals. The Test Pile Program anticipates driving piles for about 27 hours total and therefore will have a much shorter duration than the MTRP, which will further reduce the likelihood of taking beluga whales.

However, it is clear that during past monitoring efforts, an occasional group of animals was taken together, and on three occasions, a group of five beluga whales or more was taken (**Table 6-9**). Therefore, the use of the beluga exposure estimate formula alone does not account for larger groups of beluga whales that could be taken, and does not work well for calculating relatively minor, short-term construction events involving small population densities or infrequent occurrences of marine mammals.

Table 6-9 Summary of beluga whale takes by the MTRP from 2008–2011

Year	Day	Reported Take	Group Composition	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

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

Source: ICRC 2009a, 2009b, 2009d, 2009e, 2010a, 2010b, 2011a, 2011b, 2012.

As a contingency that a group of beluga whales could be taken together we estimated the size of a large group of beluga whales. To determine the size of a large group, two sets of data were examined: (1) beluga whale sightings collected opportunistically by POA employees since 2008 (**Table 6-10**), and (2) APU scientific monitoring that occurred from 2007 through 2011 (**Table 6-11, Figure 1-1**). It is important to understand how data were collected for each data set to assess how the data can be used to determine the size of a large group. POA employees are encouraged to document opportunistic sightings of beluga whales in a logbook. This has resulted in a data set of beluga sightings that spans all months over many years, and includes estimates of group size. Observations were not conducted systematically or from the same location, and this data set is likely to be biased in that smaller groups or individual whales are less likely to be sighted than larger groups. However, the data set contains good information on relative frequency of sightings and maximum group sizes. The APU data were collected systematically by dedicated observers, and bias against small groups is likely less than for the POA opportunistic sightings. However, the APU data were collected over a more limited range of dates, and sampling effort was less in April and May, when the Test Pile Program is scheduled. Both data sets are useful for assessing beluga group size in the POA area. Count data are generally Poisson-distributed (**Figure 6-8**) and nonparametric; therefore, the median, mode, minimum, maximum, and percentiles were examined for each of the two data sets (**Table 6-10**, **Table 6-11**). The mean or average was not analyzed. The median or 50th percentile separates the higher and lower halves when numbers are placed in order of value. The mode is the number that occurs most often. The minimum and maximum are the smallest and largest numbers in the data set, respectively. The percentile of a given data set is determined by the percentage of the values that are smaller than that value. For example, a 95th percentile indicates that 95 percent of the values are smaller than the indicated value and 5 percent are larger than the indicated value.

Table 6-10 Analysis of POA opportunistic beluga whale sightings

2008 - 2014	
Hours of Observation	Not Applicable
Number of Beluga Whale Observations	131
Number of Beluga Whales	1,261
Group Size: Median	9
Mode	15
Min/Max	1/100
90%	30
95%	46.3

Source: POA 2015.

Table 6-11 Analysis of beluga whale group size during scientific monitoring

2007- 2011	
Hours of Observation	3,336
Number of Beluga Whale Observations	390
Number of Beluga Whales	1,435
Group Size: Median	2
Mode	1
Min/Max	1/33
90%	8
95%	11.1

Source: Cornick 2015.

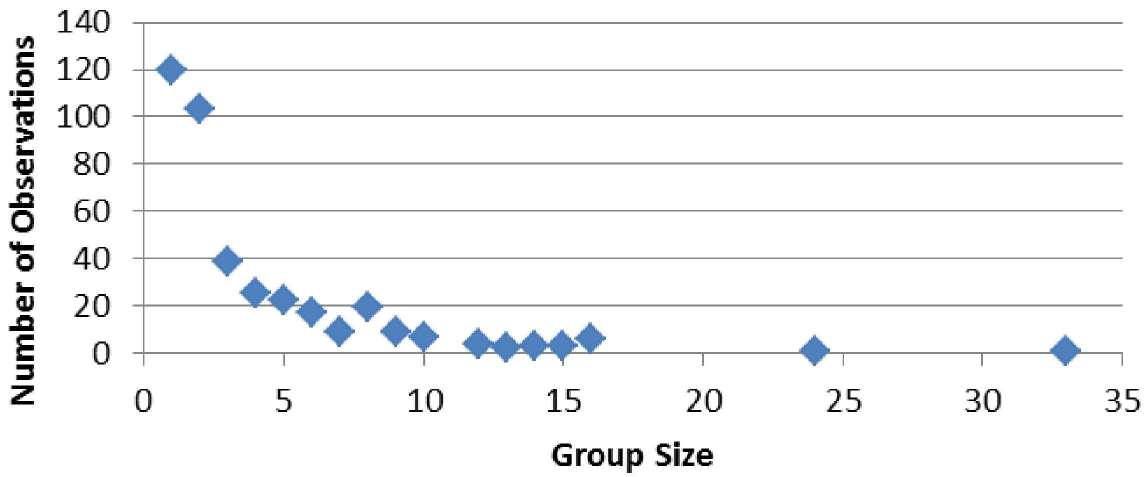

Figure 6-8 Comparing group size and number of observations for scientific monitoring data from 2007–2011

The APU scientific monitoring data set documents 390 beluga whale sightings. Group size exhibits a mode of 1 and a median of 2, indicating that over half of the beluga groups observed over the 5-year span of the monitoring program were of individual beluga whales or groups of 2. As expected, the opportunistic sighting data from the POA do not reflect this preponderance of small groups. The POA opportunistic data do indicate, however, that large groups of belugas were regularly seen in the area over the past 7 years, and that group sizes ranged as high as 100 whales. Of the 131 sightings documented in the POA opportunistic data set, 48 groups were of 15 or more beluga whales.

Incorporation of large groups into the beluga whale exposure estimate is intended to reduce risk to the Test Pile Program of the unintentional take of a larger number of belugas than would be authorized by using the density method alone. The beluga density estimate used for estimating exposure to Level B noise (**Table 6-8)** is an integration of beluga whale numbers over space and time, and does not accurately reflect the reality that beluga whales can travel in large groups, as discussed above. A common convention in statistics and other fields is use of the 95th percentile to evaluate risk. Use of the 95th percentile of group size to define a large group of beluga whales, which can be added to the estimate of exposure, calculated by the density method, provides a conservative value that reduces the risk to the POA of taking a large group of beluga whales and exceeding authorized take levels. A single large group has been added to the estimate of exposure for beluga whales based on the density method, in the anticipation that the entry of a large group of beluga whales into a Level B harassment zone would take place, at most, one time during the project.

The 95th percentile of group size for the APU scientific monitoring data is 11.1 beluga whales (rounded up to 12 beluga whales). This means that, of the 390 documented beluga whale groups in this data set, 95 percent consisted of fewer than 11.1 whales; 5 percent of the groups consisted of more than 11.1 whales. Therefore, it is improbable that a group of more than 12 beluga whales would be observed during the Test Pile Program. This number balances reduced risk to the POA with protection of beluga whales. POA opportunistic observations indicate that many groups of greater than 12 beluga whales commonly transit through the project area. APU scientific monitoring data indicate that 5 percent of their documented groups consisted of greater than 12 beluga whales. To reduce the chance of the POA reaching or exceeding authorized take, and to minimize harassment to beluga whales, in-water pile driving operations will be shut down if a group of 5 or more beluga whales is sighted approaching the Level B harassment 160 dB and 125 dB isopleths (see **Section 11.3.1**).

The POA requests authorization to take an additional 12 Cook Inlet beluga whales. The total number of requested takes of Cook Inlet beluga whales is, therefore, 20 (density method) plus 12 (large group), or 32 total takes.

6.8 All Marine Mammal Takes Requested

The analysis for the Test Pile Program predicts 31 potential exposures of harbor seals, 6 potential exposures of Steller sea lions, 37 potential exposures of harbor porpoises, and 8 potential exposures of killer whales to noise from pile driving over the course of the project that could be classified as Level B harassment under the MMPA. The POA requests 82 takes of these marine mammal species (**Table 6-12**).

The analysis for the Test Pile Program predicts 20 potential exposures of Cook Inlet beluga whales to noise from pile driving over the course of the project that could be classified as Level B harassment as defined under the MMPA. The POA requests authorization to take an additional 12 Cook Inlet beluga whales as a contingency, in the event that a large group of beluga whales may enter the harassment zone at one time, as has occurred in the past. The total number of requested takes of Cook Inlet beluga whales is 20 plus 12, or 32 total takes (**Table 6-12**).

Table 6-12 Summary of the estimated numbers of marine mammals potentially exposed to Level B harassment noise levels

Species	Level A Injury Threshold Cetaceans (180 dB)	Level A Injury Threshold Pinnipeds (190 dB)	Level B Harassment Threshold (125 or 160 dB)	Airborne Disturbance Threshold (90 dB harbor seal; 100 dB sea lion)[a]	Total	Percentage of Population[b]
Harbor seal	NA	0	31	0	**31**	0.14
Steller sea lion	NA	0	6	0	**6**	0.01
Harbor porpoise	0	NA	37	NA	**37**	0.12
Killer whale	0	NA	8	NA	**8**	Resident 0.34 or Transient 1.36
Beluga whale	0	NA	328	NA	**32**	9.4
Total	0	0	**114**	0	**114**	-

[a] No known haulouts occur within the vicinity of the POA. Therefore, pile driving will not exceed in-air disturbance threshold for hauled-out pinnipeds.

[b] Population estimates used in calculation are presented in Table 3-1. Percentage of population being requested for take is calculated out for the maximum of each killer whale ecotype. Three takes are being requested total for both ecotypes.

NA - Not Applicable.

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7 Description of Potential Impacts of the Activity to Marine Mammals

Marine mammals use hearing and sound transmission to perform vital life functions. Sound (hearing and vocalization/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-driving noise from the proposed Test Pile Program 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 driving will temporarily increase the local underwater and airborne noise environment in the vicinity of the proposed Test Pile Program. Research suggests that increased noise may impact marine mammals in several ways (e.g., behaviorally and physiologically). The effects of pile driving 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 standoff distance between the pile and the animal; and the sound propagation properties of the environment.

7.1 Potential Effects of Pile Driving on Marine Mammals

7.1.1 Zones of Noise Influence

The effects of sounds from pile driving 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) has 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 temporary threshold shifts (TTS; temporary loss in hearing) or permanent threshold shifts (PTSs; 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. This zone will be considered Level A harassment; applicable NMFS acoustic criteria for this zone are 180 dB for cetaceans and 190 dB for pinnipeds.

> ***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. This zone will be considered Level B harassment; applicable criteria for this zone are 160 dB for impact noise and 125 dB for

continuous noise (see discussion of acoustic criteria for explanation of 125 dB instead of 120 dB for the proposed Test Pile Program).

Zone of responsiveness **–** the area within which the animal reacts behaviorally or physiologically. The behavioral responses of marine mammals to sound is 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). This zone will be considered Level B harassment; applicable criteria for this zone are 160 dB for impact noise and 125 dB for continuous noise (see discussion of acoustic criteria for explanation of 125 dB instead of 120 dB for the proposed Test Pile Program).

Zone of audibility **–** the area within which the marine mammal might hear the noise. Marine mammals as a group have functional hearing ranges of 10 Hz to 180 kilohertz (kHz), with best thresholds near 40 dB (Ketten 1998; Southall et al. 2007). These data show reasonably consistent patterns of hearing sensitivity within each of three groups: small odontocetes (e.g., harbor porpoise), medium-sized odontocetes (e.g., Cook Inlet beluga whale and killer whale), and pinnipeds (e.g., harbor seal). 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 pile-driving noise could result in behavioral and mild physiological changes in marine mammals. It is known that some age and sex classes are more sensitive to noise disturbance, and such disturbance may be more detrimental to young animals (e.g., NRC 2003). David (2006) suggested that pile-driving 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 months (Hobbs et al. 2005; Huntington 2000). Monitoring and mitigation measures will be implemented for the proposed Test Pile Program to minimize the number of takes by disturbance caused by in-water pile driving by shutting down when beluga whales approach the proposed Test Pile Program area. Once calves are sighted, pile driving will immediately shut down and no further harassment will occur. There is the possibility that a calf may be initially sighted already within the harassment zone, particularly in the 125-dB harassment zone. Therefore, there is a relatively small chance that a few individual calves may be exposed to pile-driving noise; however, the proposed mitigation measures in **Section 11** should limit the exposure and impacts to individuals, mother-calf pairs, and the overall 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. PTS is considered to be an injury and to constitute a Level A take, whereas TTS is not considered injurious and constitutes a Level B take. No studies have determined levels that cause PTS in beluga whales. Laboratory experiments investigating TTS onset for beluga whales have been conducted for both pulsed and non-pulsed sounds. 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 sound exposure levels (SELs) (179 dB re 1 μPa^2-s [SEL]; 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 sound exposure level of 195 dB rms (195 dB SEL). Popov et al. (2013) conducted studies of TTS in a captive male and 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.

Kastlein et al. (2013a) determined that the hearing threshold was lower when a harbor porpoise was exposed to multiple strike sounds than when he was only exposed to 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). Therefore, PTS and TTS as a result of the proposed Test Pile Program are not expected to occur in any marine mammal species, because source levels of pile driving are lower than those in the above-referenced TTS studies and implementation of proposed mitigation measures will help avoid potential close approach of animals to activities that could result in Level A takes (i.e., injury/mortality).

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 sound pressure level 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) study 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 sound in the Thomas et al. (1990) study would be more similar to those of pile driving 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 driving.

7.2.2 Zone of Masking

Pile-driving 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 2009 construction season of the MTRP measured noise to be less than 10 kHz, with one exception of impact pile driving, which extended to 20 kHz (Širović and Kendall 2009). Blackwell (2005) and URS (2007) reported that most of the energy during vibratory activity was measured in the range of 400 to 2,500 Hz. Vibratory pile driving will more likely mask beluga whale vocalizations than impact pile driving, because it is a continuous noise and the frequency bandwidth 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). In response to loud noise, beluga whales may shift the frequency of their echolocation clicks to prevent masking by anthropogenic noise (Au 1993;

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). 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 driving 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 at close proximity to the sound source, if it at all. The area of the proposed Test Pile Program represents 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 driving and the relatively low use of the proposed Test Pile Program by beluga whales, the likelihood of in-water pile-driving 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-driving activity 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; Tougaard et al. 2012; Dähne et al. 2013). 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 only slightly deflected away from the source. Noise from pile driving could potentially displace marine mammals from the immediate proximity of pile-driving activity. However, marine mammals will likely return after completion of pile driving as demonstrated by a variety of studies about temporary displacement of marine mammals by industrial activity (reviewed in Richardson et al. 1995). Furthermore, 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 MTRP (e.g., Kendall 2010). Cook Inlet beluga whales were continually observed in the MTRP area, even in the presence of pile-driving activity (see **Section 7.2.4**). However, sightings of beluga whales increased along the western shoreline of Knik Arm during the MTRP in 2008-2009, relative to pre-construction sightings from 2005-2007, indicating possible avoidance of the activity at the MTRP site

(Kendall 2010). 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 vibratory and impact pile driving, 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 similar pattern to what has been observed prior to pile driving commencing at the POA, including similar behaviors (diving/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 are observed in the same time period (peaking in September/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; Cornick and Saxon-Kendall 2009; Cornick et al. 2011; Kendall 2010; Markowitz and McGuire 2007; Prevel-Ramos et al. 2006). There is no evidence to suggest that pile-driving 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; Cornick and Saxon-Kendall 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, the impacts on the Cook Inlet beluga whale population from the proposed Test Pile Program are expected to be negligible.

To estimate the discomfort threshold of pile-driving 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; sound exposure level of a single strike: 127 dB re 1 μPa2 s) the porpoise's respiration rate increased in response to the pile-driving 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 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 except in a rare instance.

A study by Kastelein et al. (2013c) showed that the hearing threshold for harbor seals exposed to playbacks of pile-driving 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-driving 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-driving 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 individual variation between 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 Sensitization

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 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 2002; NMFS 2008a; Funk et al. 2005; Ireland et al. 2005). For example, Cook Inlet beluga whales did not appear to be bothered by the sounds from a passing cargo freight ship (Blackwell and Greene 2002).

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-driving 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 be 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 that 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-driving 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 driving; however, background sound levels in Knik Arm are already higher than those in most other marine and estuarine systems 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 2002; 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 driving as they have for vessel traffic. It is expected that frequency and intensity of behavioral reactions, if present, will decrease when habituation occurs.

7.3 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to SPLs during pile driving at the proposed Test Pile Program that may result in Level B harassment. Any marine mammals that are "taken" (i.e., harassed) may change their normal behavior patterns (i.e., swimming speed, foraging habits, etc.) or be temporarily displaced from the area of pile driving. Any "takes" will likely have only a minor effect on individuals due to the short-term temporary nature of the project. No effect on Cook Inlet beluga whale, harbor seal, Steller sea lion, killer whale, or harbor porpoise 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 driving. 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.

SECTION 8.0

8 Description of Potential Impacts to Subsistence Uses

While no significant subsistence activity currently occurs within the POA area, Alaska Natives have traditionally harvested subsistence resources in this area for millennia. 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.

The community of Tyonek, located on the west side of Cook Inlet, had an estimated population of 171 based on 2010 U.S. Census data, with 88 percent identifying themselves as American Indian or Alaska Native (U.S. Census 2010). The median household income for Tyonek from 2009–2013 was $26,875, with approximately 33 percent of the population below the federal poverty threshold (American Community Survey 2013).

The Native Village of Eklutna maintains an office in Eklutna, an unincorporated community located within the MOA on the east side of Cook Inlet. Census data is not tracked for this community; however, according to the 2010 Census, the Eklutna Alaska Native Village Statistical Area (ANVSA) had an estimated population of 54, with approximately 82 percent identifying themselves as American Indian or Alaska Native (U.S. Census 2010). The median household income from 2009–2013 was $25,000 (American Community Survey 2013).

The Knik Tribal Council maintains offices in Wasilla, located in the Matanuska-Susitna Borough. Census data are not tracked; however, the Knik ANVSA had a mean population from 2009–2013 of 67,364, with approximately 11 percent identifying themselves as American Indian or Alaska Native (American Community Survey 2013). The median household income within the Knik ANVSA for the same time period was $70,618 (American Community Survey 2013).

Alaska Natives have traditionally harvested marine mammals, including the beluga whale, for subsistence purposes in Cook Inlet. However, beluga whales are more than a food source; they are important to the cultural and spiritual practices of Cook Inlet Native communities (NMFS 2008b). The harvest and use of beluga whales predates contact with European explorers in the 1700s, with some archaeological sites in Cook Inlet including remains of beluga whales. However, few sites include such remains, perhaps because the larger whales were commonly butchered on a beach away from village sites (Stephen R. Braund & Associates and Huntington Consulting 2011). As observed in more recent subsistence studies, after desired parts of the whale were removed to be taken to the village, carcasses were generally left on the beach for the incoming tide to take away (Fall, Foster, and Stanek 1983; Stanek 1994). Accounts of early explorers document Dena'ina harvests of beluga whales in Cook Inlet. There has also been considerable ethnographic literature regarding harvest and use of beluga whales by Dena'ina in Cook Inlet during the nineteenth and twentieth centuries (Stephen R. Braund & Associates and Huntington Consulting 2011).

The continuing relationship between residents of Tyonek and Cook Inlet beluga whales was recently documented (Stephen R. Braund & Associates and Huntington Consulting 2011). In addition to a literature review, which documented Cook Inlet Dena'ina harvest and use of beluga whales from the 1700s until the present, researchers interviewed residents regarding their knowledge of past and current beluga whale hunting and associated activities (e.g., hunting preparation, butchering, processing, sharing and distribution, etc.).

While harvests of beluga whales declined from the 1940s through the 1960s, Tyonek residents regularly harvested beluga whales again starting in the 1970s. During the 1980s and 1990s, Alaska Natives from other parts of Alaska, such as villages in the western, northwestern, and North Slope regions, also participated in the yearly subsistence harvest (Stanek 1994). 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), comprised of tribes that traditionally hunted Cook Inlet beluga whales, to establish sustainable harvests. CIMMC voluntarily curtailed their 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, 2003, and 2006 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.

In 2008, NMFS examined how many beluga whales could be harvested during a 5-year interval based on estimates of population size and growth rate, and determined at that time that no harvests would occur between 2008 and 2012 (NMFS 2008b).

In October 2008, NMFS listed the Cook Inlet beluga whale as endangered under the ESA (73 FR 62919). In April 2011, NMFS designated just over 3,000 square miles of the western shore of Cook Inlet, Kachemak Bay, and Upper Cook Inlet as critical habitat essential for the whales' survival and recovery (76 FR 20180). Some beluga whale habitat near the POA and the Eagle River Flats Range on JBER was excluded from the critical habitat designation because of national security and benefits to whales already included under the existing *Joint Base Elmendorf-Richardson Integrated Natural Resource Management Plan, 2012-2016* (JBER 2012). 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 public comment period was open until 14 July 2015. 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.

While Tyonek residents' harvests of beluga whales has been regulated and restricted since 1999, Tyonek residents have maintained traditions and values associated with beluga whale harvests and continue to share traditional knowledge associated with the whales and harvests. Beluga whales continue to be a highly valued subsistence food. Tyonek residents have indicated their relationship with beluga whales remains strong despite hunting restrictions, and they look forward to continuing harvests in the future (Stephen R. Braund & Associates and Huntington Consulting 2011).

Harvests of harbor seals for traditional and subsistence uses by Native peoples are low in upper Cook Inlet. ADF&G (2015) has collected harvest data for harbor seals in Tyonek for the following years: 1996 (2 seals harvested), 1997 (2 seals harvested), 1998 (0 seals harvested), 2000 (0 seals harvested), 2001 (0 seals harvested), 2002 (3 seals harvested), 2003 (5 seals harvested), 2004 (0 seals harvested), 2005 (0 seals harvested), 2007 (0 seals harvested), and 2008 (9 seals harvested). ADF&G conducted more comprehensive harvest studies in 1983 when marine mammal harvests included 0 seals and 1 beluga whale (Fall et al. 1983) and in 2006, when marine mammal harvests included 4 harbor seals and 1 beluga whale (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 proposed project will not impact the availability of these other marine mammal species for subsistence uses.

The primary concern related to subsistence use includes temporary disturbance and displacement of beluga whales by noise from construction activities. Since anticipated project impacts on beluga whales may involve temporary changes in behavior, construction activities associated with project activities will not impact beluga whale availability for subsistence uses. Because subsistence use of marine mammals in the POA area does not generally occur, and the impacts to marine mammals from the project are anticipated to be minimal, no increase in competition for subsistence resources and no change in regional subsistence use patterns are anticipated.

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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 will be in-water areas, whereas for seals, habitat also includes haul-out sites or rookeries. Besides 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 that has critical habitat designated in Cook Inlet. NMFS designated critical habitat in portions of Cook Inlet, including Knik Arm. The area around the proposed POA Test Pile Program (**Figure 4-7**) was excluded from the critical habitat designation. NMFS noted that Knik Arm is Type 1 habitat for the Cook Inlet beluga whale, which means it is the most valuable, and it is used intensively by beluga whales from spring through fall for foraging and nursery habitat. The ESA requires a comprehensive analysis of potential effects to critical habitat; therefore, the Biological Assessment being prepared for the proposed Test Pile Program will provide additional information on and potential effects on designated critical habitat for the Cook Inlet beluga whale.

The proposed Test Pile Program will not result in permanent impacts to habitats used by marine mammals. The proposed Test Pile Program will result in temporary changes in the acoustic environment (see following subsection). Marine mammals may experience a temporary loss of habitat because of temporarily elevated noise levels. The most likely impact to marine mammal habitat would be from pile-driving effects on marine mammal prey at and near the POA and minor impacts to the immediate substrate during installation of piles during the proposed Test Pile Program. Long-term effects of any prey displacements are not expected to affect the overall fitness of the Cook Inlet beluga whale population or its recovery; effects will be minor and will terminate after cessation of the proposed Test Pile Program.

9.2 Effects of Project Activities on Marine Mammal Prey

As noted in **Section 4**, Cook Inlet beluga whales, harbor seals, harbor porpoise, and killer whales are likely to be found in the area. The following section presents information on prey preferences for marine mammal species in the area, and possible effects of the proposed Test Pile Program on these prey items. The Cook Inlet beluga whale is discussed first, since this is the species most likely to occur in the area, followed by a discussion of the other marine mammal species.

The diet 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; Rodrigues et al. 2006, 2007). There are anecdotal reports of Cook Inlet beluga whales feeding on Pacific herring, Pacific tomcod (*Microgadus proximus*), lingcod (*Ophiodon elongatus*), steelhead trout (*Oncorhynchus mykiss)*, flatfishes, and humpback whitefish (*Coregonus oidschian)* (Huntington 2000; NMFS 2008a). Recent research using isotopic analyses of Cook Inlet beluga whale bones in a museum collection reveals a decrease in the trophic level at which Cook Inlet beluga whales were feeding from 1965 to approximately 1985 compared to after 1985, indicating a change in diet coinciding with the decline of the Cook Inlet beluga whale population (Nelson and Quakenbush 2014).

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). Harbor porpoises forage on prey similar to that of the Cook Inlet beluga whale (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 seal and harbor porpoise.

Fish populations in Knik Arm which serve as marine mammal prey could be affected by noise from in-water pile driving. Although data on fish populations in upper Cook Inlet are limited, studies indicate that a wide variety of fish species, including all five species of Pacific salmon, saffron cod, and a variety of prey species, such as eulachon and longfin smelt, are present in the vicinity of the POA, and that this area is 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 and/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 pile-driving activities) are documented to alter behavior; cause hearing loss; and injure or kill individual fish by causing serious internal injury (Hastings and Popper 2005). Halvorsen et al. (2011) categorized observed trauma injuries obtained during pile-driving activities based on the physiological significance for each observed injury: mortal, moderate, and mild. The *mortal* trauma category included observed injuries that were severe enough to lead to death (e.g., heart, liver, and kidney hemorrhage; ruptured swim bladder). The *moderate* trauma category included observed injuries likely to adversely impact fish health, but which, when considered individually, were likely recoverable under ideal conditions (i.e., no additional stressors) without being mortal (e.g., intestinal hemorrhage; hematomas [pooled blood internally in various parts of body]). Finally, *mild* trauma category refers to observed injuries that had minimal to no physiological cost to fish, which quickly recovered under ideal conditions (e.g., partially-deflated or fully-deflated swim bladder [but not ruptured]; hematomas [pooled blood] in various fins).

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 these 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 the 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, will continue following pile driving.

Regulations for pile driving (i.e., on the U.S. west coast) currently utilize a dual interim criteria approach for onset of physiological effects to fish (FHWG 2008; Stadler and Woodbury 2009; Woodbury and Stadler 2008). These criteria specify both a maximum permitted SPL for a single pile-driving strike and a SEL_{cum} for lower-level signals. The SPL_{peak} was selected to be 206 dB re 1 μPa for all sizes of fishes and the maximum SEL_{cum} was designated as 187 dB re 1 $\mu Pa^2 \cdot s$ for fish ≥2 grams (0.07 ounce) and 183 dB re 1 $\mu Pa^2 \cdot s$ for fish <2 grams (0.07 ounce). If either the SEL_{cum} or SPL_{peak} is exceeded, mitigation protocols should be applied. The acoustic thresholds developed for fish apply only to impact pile driving. The behavior effects threshold for all sizes of fish is 150 dB rms. NMFS currently uses a criterion for behavioral response of 150 dB re 1 μPa (Stadler and Woodbury 2009), but it is not clear whether this is a peak or rms level (Popper et al. 2014).

For the proposed Test Pile Program, the interim peak noise level threshold of 206 dB re 1 μPa, the injury threshold for fishes, will not be exceeded during vibratory driving of the 48-inch piles (Illingworth & Rodkin 2014b). The peak levels from the proposed Test Pile Program are expected to be less than 192 dB at 10 meters (**Table 6-4**). There are no cumulative SEL criteria for vibratory pile driving at this time; therefore, an analysis was not conducted to determine SEL levels (Illingworth & Rodkin 2014b).

Juvenile salmonids will be the most susceptible to injury or mortality resulting from pile driving 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). During the MTRP, the effects of impact and vibratory driving 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 for 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-driving activities (**Table 9-1**).

Table 9-1 Interim sound exposure guidelines for exposure to fish from pile-driving 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

[a] Eulachon, flounder.

[b] Salmon.

[c] Pacific cod.

Source: Popper et al. 2014.

Notes: Peak and rms sound pressure levels dB re 1 μPa; SEL dB re 1 μPa2·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 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,” and “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.

SEL - sound exposure level; TTS - temporary threshold shift.

In general, impacts to marine mammal prey species are expected to be minor and temporary. The area likely impacted by the proposed Test Pile Program is relatively small compared to the available habitat in Knik Arm. Due to the lack of definitive studies on how the proposed Test Pile Program might affect prey availability for marine mammals there is uncertainty to the impact analysis. However, this uncertainty will be mitigated due to the low quality and quantity of marine habitat, low abundance and seasonality of salmonids and other prey, and mitigation measures already in place to reduce impacts to fish. The most likely impact to fish from the proposed Test Pile Program will be temporary behavioral avoidance of the immediate area. In general, the nearer the animal is to the source the higher the likelihood of high energy and a resultant effect (such as mild, moderate, mortal injury). Affected fish would represent only a small portion of food available to marine mammals in the area. The duration of fish avoidance of this area after pile driving stops is unknown, but a rapid return to normal recruitment, distribution, and behavior is anticipated. Any behavioral avoidance by fish of the disturbed area will still leave significantly large areas of fish and marine mammal foraging habitat in Knik Arm. Therefore, the impacts on marine mammal prey during the proposed Test Pile Program are expected to be negligible.

SECTION 10.0

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

Descriptions of the proposed Test Pile Program impacts on habitat were discussed in **Section 9**. The effects of the proposed Test Pile Program on marine mammal habitat are expected to be short-term and minor, as described in **Section 9.1**. The greatest impact on marine mammals associated with the proposed Test Pile Program 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. Steller sea lions and killer whales are unlikely to occur in the project area and their habitat will not be impacted. The proposed Test Pile Program is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, since pile driving will be temporary, short-term, and intermittent.

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SECTION 11.0

11 Mitigation Measures

11.1 General Requirements

The Test Pile Program is planned to collect information necessary to advance the design of the pile-supported infrastructure beyond the concept level. The Test Pile Program will be integrated with a hydroacoustic monitoring program to obtain data that can be used to monitor potential impacts of in-water noise on aquatic species, meet requirements of this IHA, and to develop mitigation requirements for the APMP.

11.2 USACE Requirements

The POA is actively pursuing a USACE Section 10 permit. Mitigation requirements under that permit have not yet been determined, but will require coordination among the POA, USACE, and NMFS.

11.3 NMFS Requirements

Mitigation requirements for NMFS have not yet been determined. However, the POA is committed to minimizing impacts of its activities on beluga whales and other marine mammals. The mitigation measures discussed in this section are designed to eliminate potential for injury and minimize harassment to marine mammals, particularly beluga whales.

As described in **Section 1** and **Section 13**, the POA proposes to install confined bubble curtains and resonance-based attenuation systems around test piles to monitor sound attenuation during pile driving. In addition, the POA will test the use of use pile cushions with impact hammers. A pile cushion will be used with confined bubble casings to provide attenuation that is additive to the noise reduction provided by each system alone. Both unattenuated and attenuated pile driving will be monitored to compare the effectiveness of confined bubbles for sound attenuation.

Should other mitigation measures be deemed necessary by NMFS for future construction activities, these measures will be analyzed and implemented after consultation and agreement between NMFS and the POA. All pile-driving related mitigation measures listed here apply only to in-water pile driving.

11.3.1 Shutdowns and Soft Starts

1) ***Establishment of shutdown zones and shutdown requirements.***

   (a) Shutdown and Harassment Zones.

   Unattenuated impact pile-driving isopleth distances for 48-inch steel shell piles at 190 dB, 180 dB, and 160 dB were determined to be 14, 63, and 1,359 meters, respectively. For vibratory installation, the unattenuated distance to the 125-dB ambient level was determined to be 3,981 meters.

Based on the unattenuated sound levels predicted for pile driving, the POA is proposing a 100-meter "shutdown" zone during all pile-driving operations to prevent Level A take by injury, and to minimize take by Level B harassment.

(b) Shutdown for Large Groups.

When possible, to reduce the chance of the POA reaching or exceeding authorized take, and to minimize harassment to beluga whales, in-water pile driving operations will be shut down if a group of five or more beluga whales is sighted approaching the Level B harassment 160 dB and 125 dB isopleths.

(c) Shutdown for Beluga Whale Calves.

Beluga whale calves are likely more susceptible to loud anthropogenic noise than juveniles or adults. When possible, if a calf is sighted approaching a harassment zone, in-water pile driving will cease and will not be resumed until the calf is confirmed to be out of the harassment zone and on a path away from the pile driving. If a calf or the group with a calf is not re-sighted within 20 minutes, pile driving will resume.

(d) If maximum authorized take is reached or exceeded for the year, in-water pile driving operations will be shut down immediately.

NMFS will be notified immediately and a revised plan will be developed before in-water pile driving operations will resume.

2) ***Soft start requirements for pile driving activities.***

A ''soft start'' technique will be used at the beginning of each pile installation to allow any marine mammal that may be in the immediate area to leave before pile driving reaches full energy. The soft start requires pile-driving operators to initiate noise from vibratory hammers for 15 seconds at reduced energy followed by a 1-minute waiting period. The procedure will be repeated two additional times. If an impact hammer is used, operators will be required to provide an initial set of three strikes from the impact hammer at 40 percent energy, followed by a 1-minute waiting period, then two subsequent three–strike sets. If any marine mammal is sighted within the 100-meter shutdown zone prior to pile driving, or during the soft start, the hammer operator (or other authorized individual) will delay pile driving until the animal moves outside the 100-meter shutdown zone. Furthermore, if marine mammals are sighted within a Level B harassment zone prior to initiation of pile driving, operations will be delayed until the animals move outside the Level B harassment zone in order to avoid take. If a soft start takes place while a marine mammal(s) for which take is authorized is present within a Level B harassment zone, take(s) will be documented.

3) ***Pile driving weather delays.***

Pile driving will only take place when the Level A shutdown and Level B harassment zones can be adequately monitored.

4) ***Notification of Commencement and 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 driving.

11.3.2 Monitoring

Marine mammal monitoring will be conducted at the POA at all times when in-water pile driving is taking place. In addition, the POA proposes to monitor underwater noise during pile driving. Monitoring plans are discussed in **Section 13**.

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SECTION 12.0

12 Measures to Reduce Impacts to Subsistence Users

The proposed Test Pile Program 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 what measures have been taken or will be taken to minimize any adverse effects of the Test Pile Program 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 might 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. Enquire 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 adverse effects on the availability of marine mammals for subsistence.

- While project activities will occur within the traditional area for hunting marine mammals, the project area is not currently used for subsistence activities.
- In-water construction activities will follow mitigation procedures to minimize effects on the behavior of marine mammals, and impacts will be temporary.
- Regional subsistence representatives may support recording marine mammal observations alongside marine mammal biologists during the monitoring program and being provided with annual reports.

The combination of the Test Pile Program location, small size of the affected area, mitigation measures, and input from Tribal entities should result in project activities having no effect on the availability of marine mammals for subsistence uses.

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SECTION 13.0

13 Monitoring and Reporting

Key objectives of the Test Pile Program include quantifying hydroacoustic noise resulting from pile installation and evaluating methods that can be used to mitigate the noise during future APMP activities, thereby reducing potential impacts to marine mammals, including Cook Inlet beluga whales. The POA is committed to avoiding or minimizing impacts to marine mammals from activities associated with the Test Pile Program.

During the Test Pile Program, the POA proposes to implement a marine mammal monitoring and mitigation strategy that will reduce impacts to marine mammals to the lowest extent practicable. The monitoring plan includes two general components, acoustic measurements and visual observations.

13.1 Acoustic Measurements

The POA will conduct acoustic monitoring for impact pile driving to determine the actual distances to the 190 dB re 1µPa rms, 180 dB re 1µPa rms, and 160 dB re 1µPa rms isopleths, which are used by NMFS to define the Level A injury and Level B harassment zones for pinnipeds and cetaceans for impact pile driving. Encapsulated bubble curtains and resonance-based attenuation systems will be tested during installation of some piles to determine their relative effectiveness at attenuating underwater noise. The POA will also conduct acoustic monitoring for vibratory pile driving to determine the actual distance to the 120 dB re 1µPa rms isopleth for behavioral harassment relative to background levels (estimated to be 125 dB re 1µPa in the project area).

A typical daily sequence of operations for an acoustic monitoring day will include the following activities:

- Discussion of the day's pile-driving plans with the crew chief or appropriate contact and determination of setup locations for the fixed positions. Considerations include the piles to be driven and anticipated barge movements during the day.
- Calibration of hydrophones.
- Setup of the near (10-meter) system either on the barge or the existing dock.
- Deployment of an autonomous or cabled hydrophone at one of the distant locations. This will involve relocation of the launch upstream of the POA, and deployment of the vessel-based hydrophone at the predicted range, to either the 125 dB or the 160 dB re 1 µPa peak SPL Level B threshold. The autonomous or cabled hydrophone will be set adrift at the initiation of pile driving.
- Maintenance of communications with MMOs and construction personnel to monitor changes in the day's activities.
- Recording pile driving operational conditions throughout the day.

- Upon conclusion of the day's pile driving, retrieve the remote systems, post-calibrate all the systems, and download all systems. Check all data for accuracy and determine if the predicted isopleth for each type of pile driving needs adjustment for the next day's pile driving.

13.1.1 Hydroacoustic Measurement Locations

Hydrophones are proposed to be located in the following areas (**Figure 13-1**).

Stationary Hydrophones (Two Locations):

- A stationary hydrophone recording system will be suspended either from the pile driving barge or existing docks at approximately 10 meters from the pile being driven, for each pile driven. These data will be monitored in real-time. The hydrophone will be placed at approximately mid-depth of each pile-driving location. If the hydrophone is located on a work barge, it will be supported from a floating platform, and the depth with respect to the bottom will vary due to tidal changes and current effects. If the hydrophone is located on the existing docks, the distance to the pile may be greater than 10 meters to allow for the hydrophone to be located at an accessible location where the water depth is greater than 1 meter. This location will be a continuous recording of the pile being driven. The data will be further analyzed after the completion of the Test Pile Program.

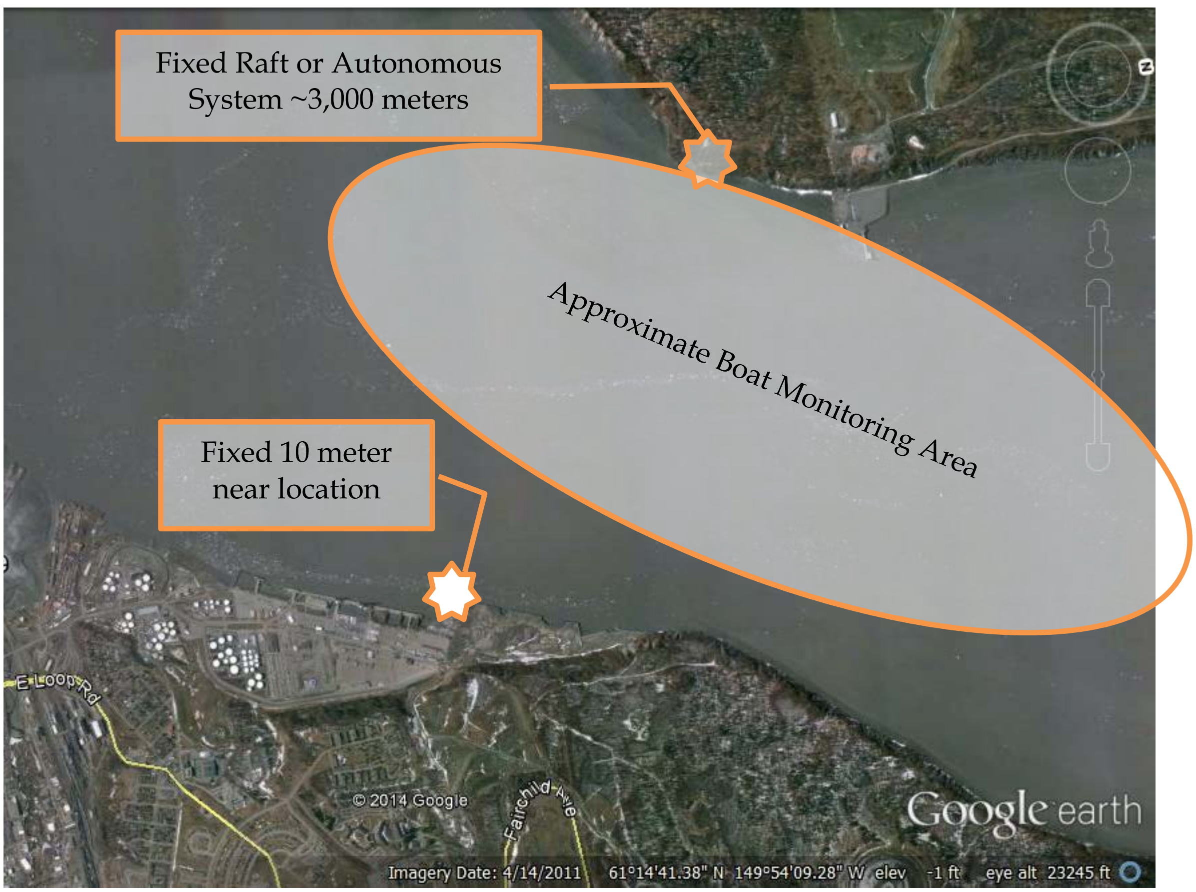

Figure 13-1 Locations where acoustic monitoring will take place

- Prior to monitoring, a standard depth sounder will record depth before pile driving commences. The sounder will be turned off prior to pile driving to avoid interference with acoustic monitoring. The hydrophone will be attached to a nylon cord or a steel chain. The nylon cord or chain will be attached to an anchor that will keep the line 10 meters from the pile, where possible. The nylon cord or chain will be attached to a float or tied to a static line at the surface 10 meters from the pile. The distance will be measured by a tape measure, where possible, or a range-finder. There will be a direct line of acoustic transmission through the water column between the pile and the hydrophone in all cases. Once the monitoring has been completed, the water depth will be recorded.

- A second stationary hydrophone will be deployed across the Knik Arm near Port MacKenzie, approximately 2,800–3,200 meters from the pile, from either an anchored floating raft or an autonomous hydrophone recorder package (**Figure 13-2** and **Figure 13-3**). At 3,000 meters, the hydrophone will be located in the water approximately three-quarters of the way across Knik Arm. The rafts are about 1.2 – 1.5 meters (4–5 feet) long and tied to an anchored mooring ball. The autonomous hydrophone is a self-contained system that is anchored and suspended from a float. Data collected using this system will not be in real-time; the distant hydrophones will collect a continuous recording of the noise produced by the piles being driven. The hydrophone will be placed at approximately mid-depth under neutral tide conditions (mean water depth). Because the distant hydrophone will be supported from a floating platform, the depth with respect to the bottom will vary due to tidal changes and current effects.

Figure 13-2 Raft system used for acoustic monitoring

Figure 13-3 Autonomous system used for acoustic monitoring

- The raft system hydrophone will include a 35-foot to 100-foot signal line. Sound level meters will log the data, which are downloaded after the event. The autonomous recording system consists of a hydrophone and a digital recorder, and will allow the event to be recorded for subsequent analysis. The data will be played back through a sound level meter at the end of the day, and analyzed at a later date.

- The distant raft and anchor point will be marked with a visible buoy and any necessary lighting. The raft will be equipped with a weatherproof, water-resistant instrument case that houses the digital recording device, power supply, and charge converter. The hydrophone will be strung from the raft and connected to a weighted signal line.

Vessel-based Hydrophones (One to Two Locations):

- An acoustic vessel with a single-channel hydrophone will be in the Knik Arm open water environment to monitor near-field and real-time isopleths for marine mammals (**Figure 13-1**, **Figure 13-4**).
- Continuous measurements will be made using a sound level meter. A sound level meter will provide real time output, which is an estimate of pulse rms. This is because sound level meters provide a fixed time constant (impulse setting of 35 milliseconds), whereas the marine mammal rms for pulses (impact pile strikes) is based on the duration of the pulse, which is usually 50–70 milliseconds. The use of the sound level meter measurements, therefore, will slightly overestimate the pulse rms, which will result in an overestimate of the distance from the sound source to the Level B 160-dB harassment isopleth. For vibratory sounds, the sound level meters can measure in real time because the sounds are continuous and are not sensitive to the time constant.
- One or two acoustic vessels are proposed to deploy hydrophones that will be used to collect data to estimate the distance to far-field sound levels (i.e., the 125-dB zone for vibratory and 160-dB zone for impact driving). These are proposed to be in real time.
- During the vessel-based recordings, the engine and any depth finders must be turned off. The vessel must be silent and drifting during spot recordings. Following the recordings, the hydrophone will be pulled back on board the vessel. The vessel will then move to another location and repeat the protocol. The continuous noise recordings of the piles will occur from the 10-meter stationary hydrophone and the autonomous recorder. All other vessel-based hydrophones are "spot recordings." The duration of the spot recordings will be determined by the acoustician in the field, based on current site conditions and the type of pile driving activity taking place.
- Either a weighted tape measure or an electronic depth finder will be used to determine the depth of the water before measurement and upon completion of measurements. A GPS unit or range finder will be used to determine the distance of the measurement site to the piles being driven.
- If it becomes necessary to reduce the flow-induced noise at the hydrophone, a flow shield will be installed around the hydrophone to provide a barrier between the irregular, turbulent flow, and the hydrophone. If no flow shield is used in these situations, the current velocity will be measured and a correlation between the levels

of the relevant sounds (background or pile driving) and current speed will be made to determine whether the data are valid and can be included in the analysis.

- The hydrophone calibrations will be checked at the beginning of each day of monitoring activity. National Institute of Standards and Technology traceable calibration forms shall be provided for all relevant monitoring equipment. Prior to the initiation of pile driving, the hydrophone will be placed at the appropriate distance and depth as described above.

- The onsite inspector/contractor will inform the acoustics specialist when pile driving is about to start to ensure that the monitoring equipment is operational. Underwater sound levels will be monitored continuously for the duration of each pile being driven with a minimum one-third octave band frequency resolution. Rms pressures will be reported in dB re 1 μPa.

- Prior to and during the pile-driving activity, environmental data will be gathered, such as water depth and tidal level, wave height, and other factors, that could contribute to influencing the underwater sound levels (e.g., aircraft, boats, etc.). Start and stop time of each pile-driving event and the time at which the bubble curtain is turned on and off will be logged.

- The construction contractor will provide the following information, in writing, to the hydroacoustic monitoring contractor for inclusion in the final monitoring report:
    - A description of the substrate composition, approximate depth of significant substrate layers,
    - Hammer model and size,
    - Pile cap or cushion type,
    - Hammer energy settings and any changes to those settings during the piles being monitored,
    - Depth pile driven,
    - Blows per foot for the piles monitored, and
    - Total number of strikes to drive each pile that is monitored.

Figure 13-4 Typical support vessel for hydroacoustic monitoring

13.1.2 Airborne Acoustic Measurement Locations

Airborne noise monitoring is not planned for the Test Pile Program, given the lack of known marine mammal haulouts in the POA area.

13.2 Sound Attenuation Monitoring

In an effort to reduce the size of the impact zone from the pile driving, which will reduce potential impacts to marine mammals, several different types of attenuation systems will be tested during the Test Pile Program to determine the most effective system to be developed for the final APMP. The POA proposes to test air bubble curtains, resonance-based attenuation systems, and pile caps/cushions, which are described below.

13.2.1 Air Bubble Curtains

Air bubble curtain systems are used during production pile driving to reduce underwater sound pressures. Such curtains, either confined or unconfined, have been shown to reduce sound pressure levels for pile driving in water by up to about 10–20 dB within 100 meters of the pile. The amount of attenuation may be less, especially at distant locations from the pile, because of the contribution of sound propagating through the bottom substrate. At the Benicia-Martinez Bridge and San Francisco-Oakland Bay Bridge projects, at least 10 dB of sound reduction was attained by using bubble curtains. In some cases, up to 30 dB of attenuation was obtained. At the Humboldt Bay Seismic Retrofit Project, reductions of between 12 and 16 dB were achieved using either an unconfined bubble ring or a bubble ring in an isolation casing, with the best results being the unconfined bubble ring (from Illingworth and Rodkin 2014b).

The design of the specific bubble ring configuration will depend on several factors, such as the depth of water and the water current. Typically, these systems consist of a stack of rings to generate air bubbles throughout the entire water column surrounding the piles, even with currents. A bubble curtain system is generally composed of air compressor(s), supply lines to deliver the air, distribution manifolds or headers, perforated aeration pipes, and a frame. The frame is used to facilitate transportation and placement of the system, keep the aeration pipes stable, and provide ballast to counteract the buoyancy of the aeration pipes during pile-driving operations. Pipes in any layer are arranged in a geometric pattern, which will allow the pile-driving operation to be completely enclosed by bubbles for the full depth of the water column. The lowest layer of perforated aeration pipe is designed to ensure contact with the mudline without sinking into the bottom substrates.

For the Test Pile Program, in consideration of the currents in the project area, a proper combination of bubble density and close proximity of bubbles to the pile will be most effective. Numerous smaller bubbles are more effective, since they displace more water between the bubbles. This pattern will have to be maintained throughout the water column, which will be challenging given the strong tidal currents (Illingworth and Rodkin 2014b).

13.2.2 Encapsulated Gas Bubble

The use of rigid bubbles is a relatively new method to reduce underwater sounds (Illingworth and Rodkin 2014b). The size and pattern of these bubbles are designed to reduce sounds across various frequencies. Experimental results show that an encapsulated gas bubble curtain can provide substantial noise reduction ranging up to 40 dB, depending on frequency. Typically, this technology focuses on reducing sound over a set frequency band rather than a broad band approach. The system will likely be designed to reduce sounds over the frequency range that pile driving produces the highest sounds. This system uses a curtain comprised of encapsulated bubbles to shield either a noise source or a receiver.

13.2.3 Resonance-Based Attenuation Systems

A resonance-based, passive noise abatement system, developed by AdBm Technologies, uses Helmholtz resonators in contrast to encapsulated bubbles, and has been shown to reduce underwater noise by up to 50dB. This modular system has no generators and purports to be easy to install even in challenging marine conditions. The system is lowered into place around the pile using pneumatic winches and uses a series of acoustic resonator slats to reduce noise without the need to generate and confine bubble curtains. The system has been successfully tested for attenuation effectiveness in underwater pile driving at Butendiek Offshore Wind Farm in 2014 (AdBm 2015).

13.2.4 Cushion Blocks

Cushion blocks are blocks of material that are used with impact hammer pile drivers. They consist of blocks of material placed atop a piling during pile driving to minimize the noise generated while driving the pile. Materials typically used for cushion blocks include wood, nylon, and micarta blocks. Other materials also may be used.

Cushion blocks may be used in conjunction with other attenuation devices (e.g., air bubble curtains, gas bubbles) to provide attenuation that is additive to the noise reduction provided by these systems.

13.2.5 Attenuation Effectiveness Testing

Whenever possible, the effectiveness of the attenuation device will be tested. It may not be possible to test all the attenuation measures as shown below using the NMFS protocol. In the cases where the on/off testing is not possible, a comparison of the levels measured with the attenuation in place will be evaluated with a different pile without attenuation.

For air bubble curtains and resonance-based measures, the basic attenuation effectiveness testing protocol requires an accounting of varying resistance as the pile is driven; the sound attenuation device will be turned off for a 1-minute period during the beginning, during the middle third, and near the end of the drive. After the attenuation system is turned off, pile driving should not resume for at least 2 minutes to allow time for air bubbles to completely disperse. For piles that require less than 5 minutes to drive, pile driving should occur for only two periods with the bubbles off, once near the beginning and once near the end of the drive. An example on/off regime will be similar to that shown in **Table 13-1**.

Table 13-1 Example regime for testing efficacy of a sound attenuation device such as a bubble curtain

Pile Driving Timeframe	Sound Attenuation Device Condition
Initial minute	Off
Next minute (minimum)	On
Middle of pile-driving period Next minute	Off; 2-minute wait while bubbles disperse before pile driving begins
Next minute (minimum)	On
End of pile-driving period Final minute	Off; 2-minute wait while bubbles disperse before pile driving begins

13.3 Marine Mammal Observations

The POA will collect data on marine mammal sightings and any behavioral responses to in-water pile driving for species observed during activities associated with the Test Pile Program. All MMOs will be trained in marine mammal identification and behaviors. Observations will occur at the best available and practicable vantage point to monitor the Level A and B harassment zones for marine mammals. 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 safety and harassment zones and calling for shutdown. They will also: 1) report on the frequency at which beluga whales and other marine mammals are present in the project footprint; 2) report on habitat use, behavior, and group composition near the POA area and correlate those data with construction activities; and 3) report on observed reactions of beluga whales and other marine mammals in terms of behavior and movement during each sighting. These observers will monitor for beluga whales and all other marine mammals during all pile-driving activities. These observers will work in collaboration with the POA to immediately communicate any presence of marine mammals in the area prior to or during pile driving.

A draft report including data collected and summarized from all monitoring locations will be submitted to NMFS within 90 days of the completion of hydroacoustic and marine mammal monitoring. The results will be summarized in graphic form and include summary statistics and time histories of impact sound values for each pile. A final report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS.

The marine mammal monitoring approach is described in the Marine Mammal Monitoring and Mitigation Plan developed for the POA Test Pile Program.

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SECTION 14.0

14 Suggested Means of Coordination

To minimize the likelihood that impacts will occur to the species, stocks, and subsistence use of marine mammals, all Test Pile Program activities will be conducted in accordance with all federal, state, and local regulations. To further minimize potential impacts from the planned Test Pile Program, 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 13**.

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 on marine mammals that occur in the project area during the Test Pile Program. Results of monitoring efforts from the Test Pile Program will be provided to NMFS in a draft 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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SECTION 15.0

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