K4.25 THREATENED AND ENDANGERED SPECIES

K4.25.1 Overview of Marine Mammal Acoustics

This appendix contains additional information on applicable noise concepts and methodologies used in development of Section 3.25 and Section 4.25, Threatened and Endangered Species. These noise concepts are applicable to non-federally listed marine mammals, and are also referenced in Section 4.23, Wildlife Values. This appendix focuses on the properties of underwater noise, which are relevant to understanding the effects of noise produced by construction and operations activities on the underwater marine environment in the Environmental Impact Statement (EIS) analysis area. This document does not provide a detailed calculation of acoustical thresholds of specific project components, but where possible, provides surrogate noise levels from similar equipment, vessels, etc., that may be used during construction and operations of the project. It also does not provide a detailed assessment of estimated numbers of marine mammal incidental take through acoustic harassment. This detailed information would be analyzed further in a Marine Mammal Protection Act (MMPA) authorization request to the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

K4.25.1.1 Underwater Noise Descriptors

Noise received at and below the sea surface has the potential to negatively impact marine mammals. The noise descriptors used in this report and for underwater acoustics in general, include the following:

- Sound pressure level (SPL), which represents the sound pressure of a sound relative to a reference pressure; it is measured in decibels (dB) referenced to one microPascal (µPa).
- Sound exposure level (SEL), which is the total energy of an event accumulated over a specified duration; therefore, the SEL accounts for both the noise level and duration of an event. SEL can be used to represent a range of different types of noise sources and is expressed in dB with a reference pressure of 1 $\mu Pa^2 s$. Variations of SEL include:
  - Single-strike sound exposure level (SEL_{ss}), which is the total energy of a single occurrence of an impulsive noise source.
  - The cumulative sound exposure level 24-hour cumulative SEL (SEL_{24h}), which is the total energy over a 24-hour period.
- Peak level, which is the maximum instantaneous noise level for an event. A peak level is typically used to represent impulsive noise sources and is expressed in dB with a reference pressure of 1 µPa.

Underwater sound propagation depends on several factors, including sound speed gradients in water, depth, temperature, salinity, and seafloor composition. In addition, characteristics of the sound source, such as frequency, source level, type of sound, and depth of the source, would also affect propagation. For ease in estimating distances to NMFS acoustic thresholds, simple transmission loss (TL) can be calculated using the logarithmic spreading loss with the formula:

$$TL = B * log10(R)$$

TL is transmission loss, B is logarithmic loss, and R is radius

The three common spreading models are cylindrical spreading for shallow water, or 10 $_{log}$(R); spherical spreading for deeper water, or 20 $_{log}$(R); and practical spreading, or 15 $_{log}$(R) (NMFS 2018a).

K4.25.1.2 Applicable Noise Criteria

Through the Endangered Species Act (ESA) and the MMPA, the NMFS and USFWS have defined levels of harassment for marine mammals. 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" (16 United States Code [USC] Section 1361 et seq.).

For Level A, NMFS (2018b) provides guidelines for assessing the onset of temporary and permanent threshold shifts from anthropogenic sound. Under these guidelines, marine mammals are separated into five functional hearing groups; source types are separated into impulsive (e.g., seismic, impact pile-driving) and non-impulsive (e.g., vibratory pile-driving, vessels); and require analyses of the distance to the peak received SPL; L_{pk}, and SEL_{24h} (NMFS 2018b).

Noise exposure criteria have been established by NMFS for identifying underwater noise levels capable of causing Level A harassment (potential injury) of certain marine mammals, including otariid pinnipeds (i.e., sea lions) (NMFS 2018b). Sea otter-specific criteria have not been determined by USFWS; however, because of their biological similarities, USFWS assumes that noise criteria developed by NMFS for injury for otariid pinnipeds are suitable surrogates for sea otter impacts (USFWS 2019).

The current Level B harassment (potential disturbance) threshold for assessing behavioral disturbance for impulsive sound is 160 decibels, referenced to one microPascal (dB re 1 μPa) root mean square (rms) for impulsive, and 120 dB re 1 μPa rms for non-impulsive sound for all marine mammals (NMFS 2018b). USFWS considers Level B harassment for both impulsive and non-impulsive sound to be 160 dB re 1 μPa rms.

Table K4.25-1 provides a summary of the disturbance guidelines. For purposes of this appendix, all underwater SPLs are reported as dB re 1 μPa and all airborne SPLs are reported as dB re 20 μPa.

Table K4.25-1: Summary of NMFS Acoustic Thresholds

Marine Mammals	Injury (Level A) Threshold		Disturbance (Level B) Threshold	
	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive
Low-Frequency Cetaceans (blue, fin, and humpback whales)	219 dB L_{pk} 183 dB SEL	199 dB SEL	160 dB rms	120 dB rms
Mid-Frequency Cetaceans (beluga and sperm whales)	230 dB L_{pk} 185 dB SEL	198 dB SEL	160 dB rms	120 dB rms
High-Frequency Cetaceans (Dall's and harbor porpoise)	202 dB L_{pk} 155 dB SEL	173 dB SEL	160 dB rms	120 dB rms
Phocid Pinnipeds (harbor seal)	218 dB L_{pk} 185 dB SEL	201 dB SEL	160 dB rms	120 dB rms
Otariid Pinnipeds (Steller sea lion)	232 dB L_{pk} 203 dB SEL	219 dB SEL	160 dB rms	120 dB rms
Sea Otters	190 dB rms	180 dB rms	160 dB rms	160 dB rms

Notes:
dB = decibels
L_{pk} = peak sound pressure
rms = root mean square
SEL = sound exposure level

K4.25.1.3 Description of Sound Sources

The acoustic characteristics of each of the activities proposed under all alternatives are described in the following section and summarized in Table K4.25-2. Not all sources of noise would result in Level A or Level B acoustic harassment, but are presented for reference. The noise sources that may be detected underwater associated with construction would comprise:

- Vessel operations (including anchor handling)
- Aircraft overflights
- Causeway construction
- Pile-driving (impact and vibratory)
- Caisson placement/excavation for wharf and causeway
- Dredging

Table K4.25-2: Summary of Noise Sources for Each Activity

Activity	Sound Pressure Levels (dB re 1 μPa)	Frequency	Reference
General vessel operations and dynamic positioning	145 to 200 dB rms at 1 m	10 Hz to 1,500 Hz	Richardson et al. 1995a; Blackwell and Greene 2003; Ireland et al. 2016
General aircraft operations	100 to 124 dB rms at 1 m	<500 Hz	Richardson et al. 1995a
Rock laying for causeway	Less than dredging: 136 to 141 dB rms at 12 to 19 m	<500 Hz	Nedwell and Edwards 2004; URS 2007
Impact pile-driving (12 96-inch pipe pile)	185 to 220 dB peak at 10 m 160 to 195 SEL at 10 m 170 to 205 rms at 10 m	<100 to 1,500 Hz	Illingworth & Rodkin 2007
Vibratory pile-driving (12 72-inch pipe and sheet pile)	165 to 195 dB peak at 10 m 150 to 180 dB SEL at 10 m 150 to 180 dB rms at 10 m	<100 to 2,500 Hz	Illingworth & Rodkin 2007
Caisson fill placement (dumping of dredge material onto barge)	108.6 dB peak at 150 m	<1,000 Hz	Dickerson et al. 2001
Backhoe dredging	178.4 dB rms at 1 m	<1,000 Hz	Dickerson et al. 2001; URS 2007

Notes:
μPa = microPascal
dB = decibels
Hz = Hertz
m = meter
rms = root mean square
SEL = sound exposure level

The majority of underwater vessel sound energy is restricted to frequencies below 100 to 200 Hertz (Hz), but broadband sounds may include acoustic energy at frequencies as high as 1 kiloHertz (kHz). The underwater SPLs of vessels depend on size and speed, but typically range from 145 to 175 dB re 1 μPa-m rms (Richardson et al. 1995a). Underwater sound levels from pile-driving vary with the size and type of piles, as well as the size and type of hammer. Impact pile-driving is generally below 4 kHz, with peak sound pressure levels ranging from 185 to 220 dB re 1 μPa at 10 meters; vibratory pile-driving generally has energy up to 10 kHz, but produces lower peak levels ranging from 165 to 195 dB re 1 μPa at 10 meters (Illingworth and Rodkin 2007). Underwater noise from aircraft (e.g., helicopter and fixed-wing) is greatest directly below the aircraft, with energy generally below 500 Hz, and ranging 100 to 124 dB re 1 μPa-m rms. Airborne sound levels associated with construction equipment generally range from 75 to 85 dB re 20 μPa at 15 m, with pile-driving producing higher sound levels between 95 to 105 dB re 20 μPa at 15 m.

Dredging Operations

During installation of the natural gas pipeline, several methods may be used during trenching/dredging activities in Cook Inlet, which are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites. Table K4.25-3 details various types of equipment that may be used during installation of the natural gas pipeline through Cook Inlet. Table K4.25-3 lists the sound at the energy source and the distance from the noise source where marine mammals may experience Level B disturbance (120 dB).

Table K4.25-3: Underwater Noise Impacts from Various Dredging Technologies

Equipment Type	Sound Energy at Source (dB re 1μPa rms @ 1 m)	Distance to Level B 120 dB Disturbance Threshold (based on spherical spreading model)	Data Source
Cutter suction dredge	167 to 178	735 to 2,605 feet	Greene 1987; Reine et al. 2012b, 2014a
Trailing hopper suction dredge	161 to 171	377 to 1,165 feet	Reine et al. 2014b
Clamshell/bucket dredge (scoop)	146	66 feet	Dickerson et al. 2001, Reine et al. 2012a, 2014a
Winching in/out	149	350 feet	Dickerson et al. 2001

Notes:
μPa = microPascal
dB = decibels
m = meter
rms = root mean square

There are additional technologies that may be used for pipeline installation that are not detailed in Table K4.25-3, above. One method employs the use of a marine support vessel that is capable of pulling a plow along the pipeline route. Although the specifics of the vessel and the plow are unknown, the recent Quintillion Subsea Operations request for authorization to take marine mammals incidental to conducting subsea cable-laying and maintenance activities provides a potentially analogous noise analysis (82 Federal Register [FR] 22099). It was determined that the distance to the Level B harassment threshold for continuous noise when the *Ile de Brehat* was pulling a sea plow was 3.32 miles. Although the specifics of the vessel and plowing technology that may be used for the project are unknown, the distance to the Level B harassment threshold would likely extend several miles in every direction from project equipment.

The second method involves either pulling a jet sled along the top of a pipeline after it has been installed or flying a jetting remotely operated vehicle along the pipeline route before or after laying the pipe. High-pressure water jets liquefy the soil, and air lift or eductor pumps remove it from under the pipeline. The specific underwater noise levels generated from this technology would be explored in detail later in the permitting process if this technology was to be used.

Vessel Operations

Vessels are major contributors to the overall acoustic environment (Richardson et al. 1995a), particularly in Alaska (Huntington et al. 2015). The characteristics of sounds produced by vessels are a product of several variables pertaining to the specifications of the vessel, including the number and type of engines, propeller shape and size, and the mechanical condition of these components (USFWS 2019). In a 2012 Cook Inlet Vessel Traffic Study Report (Eley 2012), patterns of activities were described for vessels over 300 gross tons operating during 2010. Results showed that there were 480 port calls or transits through Cook Inlet, with 80 percent of the transits made by 15 ships for the purpose of crude oil and product transport, packaged commodity shipments, and passenger/vehicle carriage. This class of vessel is characterized with source levels of 160 to 200 dB re 1 µPa rms at 1 meter in the 6- to 500-Hz range (Richardson et al. 1995a).

Position keeping in Cook Inlet is a challenge due to strong currents; therefore, some vessels use dynamic positioning with bow thrusters when anchoring is not possible. Ireland et al. (2016) measured source levels from 148.5 dB re 1 µPa rms at 1 meter at 2,000 Hz to 174.5 dB re 1 µPa rms at 1 meter at 10 Hz with 100 percent of all four thrusters.

Blackwell and Greene (2003) recorded underwater noise produced by both large and small vessels near the Port of Anchorage. The *Leo* tugboat produced the highest broadband levels of 149 dB re 1 µPa at a distance of approximately 100 meters, while the docked cargo freight ship, *Northern Lights*, produced the lowest broadband levels of 126 dB re 1 µPa rms at 100 to 400 meters. Ship noise was generally below 1 kHz. Manipulation of anchors for the installation of the natural gas pipeline would involve vessel operations that are likely to be louder than normal transit.

Aircraft Operations

Helicopters and fixed-wing aircraft generate noise from their engines, airframe, and propellers. Noise from aircraft overflights is anticipated to be a major source of airborne sounds for sea otters during project construction. Aircraft operations at the Amakdedori port would be associated with construction of the port access road to the south ferry terminal. There would be an increase in ambient noise around the port during construction due to regular aircraft flights involving take-offs and landings over Kamishak Bay. Once construction of the port access road is complete, the amount of aircraft landing at Amakdedori port would be anticipated to be greatly reduced and restricted to emergencies only. The dominant tones for both types of aircraft (helicopters and fixed-wing) generally are less than 500 Hz (Richardson et al. 1995a). Richardson et al. (1995a) reported that received sound levels in water from aircraft flying at an altitude of 152 meters were 109 dB re 1 µPa rms for a Bell 212 helicopter, 101 dB re 1 µPa rms for a small fixed-wing aircraft, 107 dB re 1 µPa rms for a twin otter, and 124 dB re 1 µPa rms for a Orion P-3 (a four-engine turboprop aircraft).

Penetration of aircraft noise into the water is greatest directly below the aircraft; at angles greater than 13 degrees from vertical, much of the sound is reflected and does not penetrate (Richardson et al. 1995a). Duration of underwater sound from passing aircraft is much shorter in water than air. For example, a helicopter passing at an altitude of 152 meters, audible in air for 4 minutes, may be detectable underwater for 38 seconds at a 3-meter depth, and 11 seconds at an 18-meter depth (Richardson et al. 1995a).

Pile-Driving

Impulsive underwater sound generated by construction activities has the potential to harass marine mammals where it exceeds 160 dB re 1 µPa rms. Impulsive noise sources proposed for the construction phase of the project include pile-driving using an impact hammer. Pile-driving would be necessary for construction of the Pile-Supported Dock Variant at the Amakdedori port under Alternative 1 and the Diamond Point port under Alternative 2—North Road and Ferry with Downstream Dams. Levels of underwater sounds produced during pile-driving are dependent on the size and composition of the pile, the substrate into which the pile is driven, bathymetry, physical and chemical characteristics of the surrounding waters, and pile installation method (impact versus vibratory hammer) (Denes et al. 2016).

Both impact and vibratory pile installation produce underwater sounds of frequencies predominantly lower than 2.5 kHz, with the highest intensity of pressure spectral density at or below 1 kHz (Denes et al. 2016). Source levels of underwater sounds produced by impact pile-driving tend to be higher than for vibratory pile-driving; however, both methods of installation can generate underwater sound levels capable of causing behavioral disturbance or hearing threshold shift in marine mammals, and both methods may be used in Cook Inlet.

Illingworth and Rodkin (2007) compiled measured near-source (i.e., 10 meters) SPL data from impact pile-driving for pile sizes ranging in diameter from 12 to 96 inches (Table K4.25-2). Vibratory pile-driving generally results in lower source sound levels, but the behavioral harassment threshold for NMFS species is 120 dB re 1 µPa rms for non-impulsive sounds, resulting in a larger area of potential disturbance. Illingworth and Rodkin (2007) also compiled measured near-source (i.e., 10 meters) SPL data from vibratory driving for pile sizes ranging in diameter from 12 to 72 inches; because the in-water construction details are not fully developed, a range of sound is provided in Table K4.25-2.

Rock Laying

Measurements of underwater noise during rock placement have shown that the rock placement itself is not distinguishable from the vessel noise (Nedwell and Edwards 2004); rock placement vessels are similar to dredging vessels. URS (2007) measured underwater sound levels from clamshell dredging at the Port of Anchorage and reported broadband levels of 136 to 141 dB re 1 µPa rms at 12 to 19 meters.

Caisson Placement

Caisson installation requires leveling the footprint on the seabed prior to caisson placement, which may require 0.6 to 0.9 meter of excavation to level the seabed. Footprint preparation would make use of an extended reach excavator mounted on a barge to minimize the extent of the disturbed area. Once the footprint is prepared, the caisson is floated into place with a tugboat at high tide and then seated into place with the falling tide, or is slowly lowered by pumping water into it. Once each caisson is set in place, it would be filled with material sourced from preparing the caisson base or from project quarries. Information on the underwater noise from placement of fill directly into the caisson is not available, but Dickerson et al. (2001) measured a sound level of 108.6 dB re 1 µPa peak at 150 meters associated with dumping of fill material into an empty barge in Cook Inlet. URS (2007) measured underwater sound levels from clamshell dredging at the Port of Anchorage, and reported broadband levels of 136 to 141 dB re 1 µPa rms at 12 to 19 meters. Dickerson et al. (2001) report higher levels for bucket dredging of 178.4 dB re 1 µPa rms at 1 meter.

K4.25.1.4 Effects of Noise on Affected Marine Mammals

Marine mammals use hearing and sound transmission to perform vital life functions. The introduction of sound from project-related activities to their environment could be disrupting to those behaviors. Sound (hearing and vocalization/echolocation) serves four primary functions for marine mammals, including: 1) providing information about their environment; 2) communication; 3) prey detection; and 4) predator detection. The distances to which noise associated with the project activities are audible depend on source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (marine mammal) (Richardson et al. 1995a).

The effects of sound from industrial activities (including project-related activities, depending on the alternative or variant) on marine mammals could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and temporary or permanent hearing impairment or non-auditory physical effects (Richardson et al. 1995a). In assessing potential effects of noise, Richardson et al. (1995a) 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 where the received sound level is potentially high enough to cause discomfort or tissue damage to auditory or other systems. This includes temporary threshold shifts (TTSs) (e.g., temporary loss in hearing) or permanent threshold shifts (PTS) (e.g., loss in hearing at specific frequencies or deafness). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage.

> ***Zone of masking—***the area where noise may interfere with detection of other sounds, including communication calls, prey sounds, or other environmental sounds.

> ***Zone of responsiveness—***the area where the animal reacts behaviorally or physiologically. The behavioral responses of marine mammals to sound is dependent on 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 a sound is similar to that of a predator) (Richardson et al. 1995a; Southall et al. 2007). However, temporary behavioral effects are often simply evidence that an animal has heard a sound, and may not indicate lasting consequence for exposed individuals (Southall et al. 2007).

> ***Zone of audibility—***the area where the marine mammal might hear the noise. Marine mammals as a group have functional hearing ranges of 10 Hz to 180 kHz, with best thresholds near 40 dB (Kastak et al. 2005; Ketten 1998; Southall et al. 2007). These data show reasonably consistent patterns of hearing sensitivity in each of three groups: small odontocetes (e.g., harbor porpoise and Dall's porpoise), medium-sized odontocetes (e.g., beluga whales and killer whales), and pinnipeds (e.g., harbor seal and Steller sea lion). There are no applicable assessment criteria (Table K4.25-1) for the zone of audibility due to difficulties in human ability to determine the audibility of a particular noise for a particular species.

Due to relatively low sound levels, the short period of time that louder activities would occur over the life of the project, and the implementation of mitigation and monitoring measures, it is unlikely there would be any temporary or especially permanent hearing impairment, or non-auditory physical effects on marine mammals. Additionally, most of Cook Inlet is a poor acoustic environment because of its shallow depth, soft bottom, and high background noise from currents and glacial silt, which greatly reduces the distance sound travels (Blackwell and Greene 2003). This means that underwater sound does not travel as fast, or is masked because of interference with the sound's ability to propagate.

The effects of sound on marine mammals are highly variable, and can generally be categorized as follows (adapted from Richardson et al. 1995a):

- The sound may be too weak to be heard at the location of the animal (i.e., lower than the prevailing ambient sound level), the hearing threshold of the animal at relevant frequencies, or both.

- The sound may be audible but not strong enough to elicit any overt behavioral response (i.e., the mammal may tolerate it) either without or with some deleterious effects (e.g., masking, stress).
- The sound may elicit behavioral reactions of variable conspicuousness and variable relevance to the well-being of the animal; these can range from subtle effects on respiration or other behaviors (detectable only by statistical analysis) to active avoidance reactions.
- On repeated exposure, animals may exhibit diminishing responsiveness (habituation/sensitization) or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal may perceive as a threat.
- Any human-made sound that is strong enough to be heard has the potential to reduce (i.e., mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds due to wave action or (at high latitudes) ice movement. Marine mammal calls and other sounds are often audible during the intervals between pulses, but mild to moderate masking may occur during that time because of reverberation.

Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physical or physiological effects. Received sound levels must far exceed the animal's hearing threshold for any TTS to occur. Received levels must be even higher for a risk of permanent hearing impairment.

K4.25.1.5 Hearing Abilities of Affected Marine Mammals

The hearing abilities of marine mammals are functions of the following (Au et al. 2000; Richardson et al. 1995a):

- Absolute hearing threshold at the frequency in question (the level of sound barely audible in the absence of ambient noise). The "best frequency" is the frequency with the lowest absolute threshold.
- Critical ratio (the signal-to-noise ratio required to detect a sound at a specific frequency in the presence of background noise around that frequency).
- The ability to determine sound direction at the frequencies under consideration.
- The ability to discriminate among sounds of different frequencies and intensities.

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Experiments and monitoring studies also show that marine mammals hear and may react to many types of human-made sounds (Richardson et al. 1995a; Gordon et al. 2004; Nowacek et al. 2007; Tyack 2008).

Baleen Whales (Mysticetes)

The hearing abilities of baleen whales (humpback, fin, and gray whales) have not been studied directly given the difficulties in working with such large animals. Behavioral and anatomical evidence indicates that they hear well at frequencies below 1 kHz (Ketten 2000; Richardson et al. 1995a). Frankel (2005) noted that gray whales reacted to a 21 to 25 kHz signal from whale-finding sonar. Some baleen whales react to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at 36 kHz or above (Watkins 1986). In addition, baleen whales produce sounds at frequencies up to 8 kHz; and for humpback whales, with components up to >24 kHz (Au et al. 2006). The anatomy of the baleen whale inner ear seems to be well adapted for detection of low-frequency sounds (Ketten 1992a, b, 1994, 2000; Parks et al. 2007). Although humpback and minke whales may have some auditory sensitivity to frequencies above 22 kHz, for baleen whales as a group, the functional hearing range is thought to be about 7 Hz to 22 kHz, or possibly 35 kHz; baleen whales are said to constitute the “low-frequency” hearing group (NMFS 2016; Southall et al. 2007). The absolute sound levels that they can detect below 1 kHz are probably limited by increasing levels of natural ambient noise at decreasing frequencies (Clark and Ellison 2004). Ambient noise levels are higher at low frequencies than at middle frequencies. At frequencies below 1 kHz, natural ambient levels tend to increase with decreasing frequency.

The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than the ears of the small-toothed whales that have been studied directly (MacGillivray et al. 2014). Therefore, baleen whales are likely to hear vessel sounds farther away than small-toothed whales; at closer distances, vessel sounds may seem more prominent to baleen than to toothed whales. However, baleen whales have commonly been seen in the distances where sounds from vessels would be detectable, and often show no overt reaction to those sounds. Behavioral responses by baleen whales to various anthropogenic sounds, including sounds produced by vessel thrusters used for anchor handling during construction of the natural gas pipeline and general vessel traffic associated with the project, have been documented; however, received levels of sounds necessary to elicit behavioral reactions are typically well above the minimum levels that the whales are assumed to detect.

Toothed Whales (Odontecetes)

Toothed whales (beluga whales and porpoise species) often show tolerance to vessel activity; however, they may react at long distances if they are confined by ice, shallow water, or were previously harassed by vessels (Richardson et al. 1995a). Toothed-whale responses to vessel activity also vary depending on the activity of the whale. Many species of dolphins tolerate or even approach vessels in the area and often ride the bow and stern waves (this reduces the energy cost of travel); however, dolphins have also been observed avoiding vessels. Other species of toothed whales that have avoided vessels include river dolphins, harbor porpoise, and sperm whales. Foote et al. (2004) found increases in the duration of killer whale calls from 1977 to 2003, when vessel traffic in Puget Sound increased dramatically, particularly whale-watching boats.

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). Castellote et al. (2014) measured their peak sensitivity at between 45 and 80 kHz. 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 approximately 35 Hz, where their hearing threshold is about 140 dB re 1 μPa (Richardson et al. 1995a). Thresholds for pulsed sounds would be higher, depending on the specific durations and other characteristics of the pulses (Johnson 1991).

Seals and Sea Lions (Pinnipeds)

Underwater audiograms have been determined for several species of phocid seals (true seals), monachid seals (monk seals), otariids (eared seals), and the walrus (reviewed in Cunningham and Reichmuth 2016; Kastak and Schusterman 1998, 1999; Kastelein et al. 2002, 2005, 2009; Reichmuth et al. 2013; Richardson et al. 1995a; Sills et al. 2014, 2017). The functional hearing range for phocid seals in water is generally considered to extend from 50 Hz to 86 kHz (NMFS 2016; Southall et al. 2007), although a harbor seal, spotted seal, and California sea lion were shown to detect frequencies up to 180 kHz (Cunningham and Reichmuth 2016). However, some species, especially the otariids, have a narrower auditory range (60 Hz to 39 kHz; NMFS 2016). In comparison with odontocetes, pinnipeds tend to have lower hearing frequencies, lower high-frequency cut-offs, better auditory sensitivity at low frequencies, and poorer sensitivity at frequencies of best hearing.

At least some of the phocid seals have better sensitivity at low frequencies (equal to or less than 1 kHz) than odontocetes. Below 30 to 50 kHz, the hearing thresholds of most species tested are essentially flat down to approximately 1 kHz, and range between 60 and 85 dB re 1 μPa. Measurements for harbor seals indicate that below 1 kHz, their thresholds under quiet background conditions deteriorate gradually with decreasing frequency to approximately 75 dB re 1 μPa at 125 Hz (Kastelein et al. 2009). Recent measurements of underwater hearing for spotted seals (*Phoca largha*) showed a peak sensitivity of approximately 51 to 53 dB re 1 μPa at 25.6 kHz, with the best hearing range at approximately 0.6 to 11 kHz, and good auditory sensitivity extending seven octaves (Sills et al. 2014).

For the otariid seals, the high frequency cut-off is lower than for phocids, and sensitivity at low frequencies (below 1 kHz) rolls off faster, resulting in an overall narrower bandwidth of best sensitivity (NMFS 2016).

Sea Otter (Mustelid)

In-air vocalizations of sea otters have most of their energy concentrated at 3 to 5 kHz (McShane et al. 1995; Thomson and Richardson 1995). Sea otter vocalizations are considered to be most suitable for short-range communication among individuals (McShane et al. 1995). However, Ghoul and Reichmuth (2012) noted that the in-air "screams" of sea otters are loud signals (source level up to 113 dB re 20 μPa) that may be used over larger distances; screams have dominant frequencies of 4 to 8 kHz. Controlled sound exposure trials on southern sea otters (Enhydra lutris *nereis*) indicate that hearing ability spans frequencies between 125 Hz and 38 kHz, with best sensitivity between 1.2 and 27 kHz (Ghoul and Reichmuth 2014). Aerial and underwater audiograms for a captive adult male southern sea otter in the presence of ambient noise suggest the sea otter's hearing was less sensitive to high-frequency (greater than 22 kHz) and low-frequency (less than 2 kHz) sounds than terrestrial mustelids (USFWS 2019). Underwater, sea otter hearing is most sensitive at 8 to 16 kHz; however, their hearing is not specialized to detect sounds in background noise (Ghoul and Reichmuth 2016).

Thresholds have been developed for other marine mammals. Above these thresholds, exposure is likely to cause behavioral disturbance and injury; however, species-specific criteria for preventing harmful exposures to sound have not been identified for sea otters (USFWS 2019).

K4.25.1.6 Potential Effects of Project-Induced Noise on Marine Mammals

Vessel noise can contribute substantially to a low-frequency ambient noise environment already filled with natural sounds. Vessel noise from the project could affect marine animals along the underwater portion of the natural gas pipeline corridor. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels, with low vessel speeds (such as those expected during the proposed activity) resulting in lower sound levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995a). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014). The following sections detail studies addressing the potential effects of vessel sounds on marine mammals, or lack thereof.

Tolerance

Numerous studies have shown that underwater sounds from industry activities are often readily detectable in the water at distances of many kilometers. As described below, numerous studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response to industry activities of various types (Harris et al. 2001; Moulton et al. 2005). This is often true even in cases when the sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to underwater sound such as airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions (Stone and Tasker 2006). In general, pinnipeds and small odontocetes seem to be more tolerant of exposure to some types of underwater sound than are baleen whales.

Masking

Masking is the obscuring of sounds of interest by interfering sounds, which can affect a marine mammal's ability to communicate, detect prey, or avoid predation or other hazards. Through masking, ship noise can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (Cholewiak et al. 2018; Clark et al. 2009; Dunlop 2016; Erbe et al. 2016; Gervaise et al. 2012; Hatch et al. 2012; Jensen et al. 2009; Jones et al. 2017; Rice et al. 2014; Richardson et al. 1995a). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. To compensate for increased ambient noise in the presence of elevated noise levels from shipping, some cetaceans are known to increase the source levels of their calls, shift their peak frequencies, or otherwise change their vocal behavior (Azzara et al. 2013; Bittencourt et al. 2016; Castellote et al. 2012; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Luís et al. 2014; Martins et al. 2016; Melcón et al. 2012; O'Brien et al. 2016; Papale et al. 2015; Parks et al. 2011, 2016a,b; Sairanen 2014; Tenessen and Parks 2016; Tyack and Janik 2013).

Using acoustic propagation and simulation modeling, Clark et al. (2009) estimated lost communication space from vessel traffic for fin, humpback, and North Atlantic right whales in the northwestern Atlantic Ocean. They found that because of higher call source levels and the frequency range of calls falling outside of the range of strongest ship sounds, fin and humpback whales are likely to experience much less of a reduction in communication space than North Atlantic right whales. Because right whale call frequencies are more centered on the strongest frequencies produced by large ships and their call source levels are typically lower, they may experience nearly complete loss of communication space when a large ship is within 4 kilometers of that whale. However, the sound source levels of the ship used by Clark et al. (2009) were much higher than those expected to be produced by the smaller and slower-moving vessels used during pipe-laying activities.

Auditory studies on pinnipeds indicate that they can hear underwater sound signals of interest in environments with relatively high background noise levels, a possible adaption to the noisy nearshore environment they inhabit (Southall et al. 2000). Southall et al. (2000) found that northern elephant seals, harbor seals, and California sea lions lack specializations for detecting low-frequency tonal sounds in background noise; but rather, were more specialized for hearing broadband noises associated with schooling prey.

Disturbance Reactions

Baleen whales are thought to be more sensitive to sound at low frequencies than toothed whales (e.g., MacGillivray et al. 2014). Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to overtly react when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging (Blair et al. 2016) and singing behavior by humpback whales (Tsujii et al. 2018). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

Southall et al. (2007) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound. In general, little or no response was observed in animals exposed at received levels from 90 to 120 dB re 1 μPa rms. Probability of avoidance and other behavioral effects increased when received levels were 120 to 160 dB re 1 μPa rms. Some of the relevant studies are summarized below.

Baker et al. (1982) reported some avoidance by humpback whales to vessel noise when received levels were 110 to 120 dB re 1 μPa rms, and clear avoidance at 120 to 140 dB re 1 μPa rms (sound measurements were not provided by Baker, but were based on measurements of identical vessels by Miles and Malme 1983).

Malme et al. (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21 minutes overall duration and 10 percent duty cycle; source levels 156 to 162 dB re 1 μPa-m). In two cases for received levels of 100 to 110 dB re 1 μPa, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB re 1 μPa rms. Richardson et al. (1990) performed 12 playback experiments in which bowhead whales in the Alaskan Arctic were exposed to drilling sounds. Whales generally did not respond to exposures in the 100 to 130 dB re 1 μPa rms range, although there was some indication of behavioral changes in several instances.

Frankel and Clark (1998) conducted playback experiments with wintering humpback whales using a single speaker producing a low-frequency “M-sequence” (sine wave with multiple-phase reversals) signals in the 60 to 90 Hz band with output of 172 dB re 1 μPa rms. For 11 playbacks, exposures were between 120 and 130 dB re 1 μPa, and included sufficient information regarding individual responses. During eight of the trials, there were no measurable differences in tracks or bearings relative to control conditions; on three occasions, whales either moved slightly away from (n = 1) or toward (n = 2) the playback speaker during exposure. The presence of the source vessel itself had a greater effect than did the M-sequence playback.

Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various non-pulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-minute “alert” sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB re 1 μPa rms (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise, and the other four were exposed to both stimuli; these whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (Campana et al. 2015; Culloch et al. 2016; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 kilometers away, and could affect the behavior of a marine mammal at a distance of 52 kilometers in the case of tankers.

Temporary Threshold Shift

TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (NMFS 2016). While experiencing TTS, the hearing threshold rises, and a sound must be stronger to be heard. It is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or "injury" (Le Prell 2012; Southall et al. 2007). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. However, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injuring effect (Tougaard et al. 2015, 2016; Weilgart 2014).

The magnitude of TTS depends on the level and duration of sound exposure, and to some degree on frequency, among other considerations (Richardson et al. 1995a; Southall et al. 2007). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the sound ends. Extensive studies on terrestrial mammal hearing in air show that TTS can last from minutes or hours to days (in cases of strong TTS). More limited data from odontocetes and pinnipeds show similar patterns (Finneran and Schlundt 2010; Mooney et al. 2009a, b).

There are no data, direct or indirect, on levels or properties of sound that are required to induce TTS in any baleen whale. The frequencies to which mysticetes are most sensitive are assumed to be lower than those that odontocetes are most sensitive to; natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales in their frequency band of best hearing are believed to be higher (i.e., less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, Southall et al. (2007) suspected that received levels causing TTS onset may also be higher in mysticetes. However, Wood et al. (2012) suggested that the received levels that cause hearing impairment in baleen whales may be lower.

In pinnipeds, initial evidence from exposures to non-pulses suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than most small odontocetes exposed for similar durations do (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastak et al. (2005) reported that the amount of threshold shift increased with increasing SEL in a California sea lion and harbor seal. They noted that, for non-impulse sound, doubling the exposure duration from 25 to 50 minutes (i.e., a +3 dB change in SEL) had a greater effect on TTS than an increase of 15 dB (95 versus 80 dB) in exposure level. Mean threshold shifts ranged from 2.9 to 12.2 dB, with full recovery in 24 hours (Kastak et al. 2005). Kastak et al. (2005) suggested that, for non-impulse sound, SELs resulting in TTS onset in three species of pinnipeds may range from 183 to 206 dB re 1 $\mu Pa^2 \cdot s$, depending on the absolute hearing sensitivity.

Permanent Threshold Shift

When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness; whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (NMFS 2016). Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times (i.e., the interval required for sound pressure to increase from the baseline pressure to peak pressure).

K4.25.1.7 Potential Impacts of Noise on Food Sources

Zooplankton

Zooplankton is a food source for several marine mammal species, as well as a food source for fish that are then prey for marine mammals. Popper and Hastings (2009a, b) reviewed information on the effects of pile-driving, and concluded that there are no substantive data on whether the high sound levels from pile-driving or any human-made sound would have physiological effects on invertebrates. Any such effects would be limited to the area close (1 to 5 meters) to the sound source and is unlikely to cause population effects due to the relatively small area affected at any one time, and the reproductive strategy of most zooplankton species (short generation, high fecundity, and very high natural mortality).

No adverse impact on zooplankton populations would be expected to occur from project activities, due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts that might occur would be expected to be negligible compared to the naturally occurring high reproductive and mortality rates. Impacts from sound energy generated by vessels and dredging would be expected to have even less impact, because these activities produce much lower sound energy levels.

Benthos

Limited research has been conducted on the effects of noise on invertebrates (Hawkins and Popper 2012). Christian et al. (2003) concluded that there were no obvious effects from seismic signals on crab behavior, and no significant effects on the health of adult crabs. Pearson et al. (1994) had previously found no effects of seismic signals on crab larvae for exposures as close as 1 meter from a seismic array, or for mean sound pressure as high as 231 dB. Pearson et al. (1994) did not observe any statistically significant effects on Dungeness crab (*Cancer magister*) larvae shot as close as 1 meter from a 231-dB source. Invertebrates such as mussels, clams, and crabs do not have auditory systems or swim bladders that could be affected by sound pressure. Squid and other cephalopod species have statocysts that resemble the otolith organs of fish that may allow them to detect sounds (Budelmann 1992). Some species of invertebrates have shown temporary behavioral changes in the presence of increased sound levels. Fewtrell and McCauley (2012) reported increases in alarm behaviors in wild-caught captive reef squid (*Sepioteuthis australis*) exposed to seismic airguns at noise levels between 156 and 161 dB. Additionally, captive crustaceans have changed behaviors when exposed to simulated sounds consistent with those emitted during seismic exploration and pile-driving activities (Tidau and Briffa 2016). In general, there is little knowledge regarding effects of sound in marine invertebrates or how invertebrates are affected by high noise levels (Hawkins and Popper 2012). A review of literature pertaining to effects of seismic surveys on fish and invertebrates (Carroll et al. 2017) noted that there is a wide disparity between results obtained in field and laboratory settings. Some of the reviewed studies indicate the potential for noise-induced physiological and behavioral changes in a number of invertebrates. However, changes were observed only when animals were housed in enclosed tanks, and many were exposed to prolonged bouts of continuous, pure tones.

No adverse impacts on benthic populations would be expected, due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts that might occur because of construction and operations are negligible compared to the naturally occurring high reproductive and mortality rates.

Fish

Fish are the primary prey species for marine mammals in Cook Inlet and Iliamna Lake. In general, fish perceive underwater sounds in the frequency range of 50 to 2,000 Hz, with peak sensitivities below 800 Hz (Popper et al. 2005). However, fish are sensitive to underwater impulsive sounds due to swimbladder resonance. As the pressure wave passes through a fish, the swimbladder is rapidly squeezed as the high-pressure wave, and then under-pressure component of the wave, which passes through the fish. The swimbladder may repeatedly expand and contract at the high SPLs, creating pressure on the internal organs surrounding the swimbladder.

Popper et al. (2005), in a review of 40 years of studies concerning the use of underwater sound to deter salmonids from hazardous areas at hydroelectric dams and other facilities, concluded that salmonids were able to respond to low-frequency sound, and to react to sound sources in close proximity of the source. They speculated that the reason that underwater sound had no effect on salmonids at distances greater than a few feet is because they react to water particle motion/acceleration, not sound pressures. Detectable particle motion is produced very short distances from a sound source, although sound pressure waves travel farther.

Hastings and Popper (2005) reviewed all pertinent peer-reviewed and unpublished papers on noise exposure of fish through early 2005. They proposed the use of SEL to replace peak SPL in pile-driving criteria. This report identified interim thresholds based on SEL or sound energy. The interim thresholds for injury were based on exposure to a single pile-driving pulse. The report also indicates that there was insufficient evidence to make any findings regarding behavioral effects associated with these types of sounds. Interim thresholds were identified for pile-driving consisting of a single-strike peak SPL and a single strike SEL for onset of physical injury. A peak pressure criterion was retained to function in concert with the SEL value for protecting fishes from potentially damaging aspects of acoustic impact stimuli. The available scientific evidence suggested that a single-strike SPL of 208 dB and a single-strike SEL of 187 dB were appropriate thresholds for the onset of physical injury to fishes.

Following the Hasting and Popper (2005) paper, NMFS developed their version of the dual criteria that included the single-strike peak SPL of 208 dB, but addressed the accumulation of multiple strikes through accumulation of sound energy by setting a criterion of 187 dB SEL. The accumulated SEL is calculated using an equal energy hypothesis that combines the SEL of a single strike to 10 times the 10-based logarithm of the number of pile strikes.

Fish have been shown to react when engine and propeller sounds exceed a certain level (Olsen et al. 1983; Ona 1988; Ona and Godo 1990). Avoidance reactions have been observed in fish (e.g., cod and herring) when vessel sound levels were 110 to 130 dB re 1 µPa rms (Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988). Vessel sound source levels in the audible range for fish are typically 150 to 170 dB re 1 µPa/Hz (Richardson et al. 1995a). Several studies that assessed noise impacts on cod, crab, and schooling fish found little or no injury to adults, larvae, or eggs when exposed to impulsive noise sources exceeding 220 dB. The continuous noise levels from ship thrusters, which are generally below 180 dB, do not create enough pressure to cause tissue or organ injury (82 FR 22099).

Several caged fish studies of the effects of pile-driving have been conducted, and most have involved salmonids. Ruggerone et al. (2008) exposed caged juvenile coho salmon (93 to 135 millimeters) at two distance ranges (near 1.8 to 6.7 meters, and distant 15 meters) to 0.5-meter steel piles driven with a vibratory hammer. Sound pressure levels reached 208 dB re 1 µPa peak, 194 dB re 1 µPa rms, and 179 dB re 1 $\mu Pa^2 s$ SEL, leading to a cumulative SEL of approximately 207 dB re 1 $\mu Pa^2 s$ during the 4.3-hour period. All observed behavioral responses of salmon to pile strikes were subtle; avoidance response was not apparent among fish. No gross external or internal injuries associated with pile-driving sounds were observed. The fish readily consumed hatchery food on the first day of feeding (day 5) after exposure. The study suggests that coho salmon were not significantly affected by cumulative exposure to the pile-driving sounds.

Hart Crowser, Inc. et al. (2009) similarly exposed caged juvenile (86 to 124 millimeters, 10 to 16 grams) coho salmon to sheet pile-driving in Cook Inlet using vibratory and impact hammers. Sound pressures measured during the acoustic monitoring were relatively low, ranging from 177 to 195 dB re 1 μPa peak, and cumulative SEL sound pressures ranging from 179.2 to 190.6 dB re 1 μPa^2s. No measured peak pressures exceeded the interim criterion of 206 dB. Six of the 13 tests slightly exceeded the SEL criterion of 187 dB for fish over 2 grams. No short-term or long-term mortalities of juvenile hatchery coho salmon were observed in exposed or reference fish, and no short- or long-term behavioral abnormalities were observed in fish exposed to pile-driving sound pressures or in the reference fish during post-exposure observations.

Ensonification from the activities should have no more than a negligible effect on marine mammal food sources because:

- No studies have demonstrated that noise affects the life stages, condition, or amount of food resources (e.g., fish, invertebrates, eggs) composing habitats used by marine mammals, except when exposed to sound levels a few meters from the source, or in a few very isolated cases.
- Where fish or invertebrates responded to noise, the effects were temporary and of short duration (Popper et al. 2005). Consequently, disturbance to fish species would be short-term, and fish would return to their pre-disturbance behavior once the activity ceases. Therefore, project activities (construction of the port, lightering locations, and natural gas pipeline in Cook Inlet) would have little, if any, impact on marine mammals feeding in the area where work is planned.
- The project activity area covers a small percentage of the potentially available habitat used by marine mammals in Cook Inlet, which allows marine mammals to move away from any project area–specific program sounds to feed, rest, migrate, or conduct other elements of their life history.

Therefore, the activities included in the project area are not expected to have any permanent habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations because operations would be limited in duration, location, timing, and intensity.

K4.25.1.8 Acoustic Analysis

Per the ESA and the MMPA, applicants are required to evaluate the number of marine mammals potentially exposed to sound levels exceeding the thresholds from Table K4.25-2. This method requires an estimated density of marine mammals (animals per square kilometer), the area of ensonification (square kilometers), which is determined by calculating the distance from the source to the threshold, and duration in a 24-hour period of the activity. Once project-specific details are finalized, details such as pile type and size, size of hammer and number of strikes per pile to install, number of piles per day, and duration of the pile strike would be used to calculate the approximate number of potential marine mammal exposures. Calculated distances to agency thresholds are also used to establish mitigation and monitoring zones. ESA and MMPA consultation with the USFWS and NMFS would define potential estimates of marine mammal take, and provide avoidance and minimization measures to reduce and eliminate take where feasible.