K4.25 THREATENED AND ENDANGERED SPECIES

K4.25.1 Overview of Underwater Acoustics

This appendix contains additional information on applicable underwater noise concepts and methodologies used in development of Section 3.25 and Section 4.25, Threatened and Endangered Species. This appendix summarizes 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 proposed under the action alternatives. This information can be found in the Biological Assessments prepared for the project, which are included as Appendix G and Appendix H. This detailed information would be analyzed further in a Marine Mammal Protection Act (MMPA) authorization request to the regulatory agencies to meet Level A and B guidelines (if required).

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).
- Sound exposure level (SEL), which is the total energy of an event referenced to a period of 1 second; 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 $\mu Pa^2 \cdot s$ (Pa = microascal). 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, and;
  - The cumulative sound exposure level 24-hour cumulative SEL (SEL_{24h}), which is the total energy of the entire period of exposure.
- 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 like frequency, source level, type of sound, and depth of the source will also affect propagation. For ease in estimating distances to National Marine Fisheries Service (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 US Fish and Wildlife Service (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 US Code [USC] Section 1361 et seq.).

For Level A, NMFS 2018b provides guidelines for assessing the onset of 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) and non-impulsive; and require analyses of the distance to the peak received SPL; L_{pk}, and SEL_{24h} (NMFS 2018b).

The current Level B (i.e., disturbance) threshold for assessing the onset of temporary threshold shifts 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).

Table K4.25-1 provides a summary of the disturbance guidelines. For purposes of this section, all underwater SPLs are reported as dB re 1 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	219 dB L_{pk} 183 dB SEL	199 dB SEL	160 dB rms	120 dB rms
Mid-Frequency Cetaceans	230 dB L_{pk} 185 dB SEL	198 dB SEL	160 dB rms	120 dB rms
High-Frequency Cetaceans	202 dB L_{pk} 155 dB SEL	173 dB SEL	160 dB rms	120 dB rms
Phocid Pinnipeds	218 dB L_{pk} 185 dB SEL	201 dB SEL	160 dB rms	120 dB rms
Otariid Pinnipeds	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

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 will result in Level A or B acoustic harassment, but are presented for reference. The noise sources that may be heard underwater associated with construction will comprise:

- Vessel operations
- Aircraft overflights
- Causeway construction

- Pile driving (impact and vibratory)

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

Activity	Sound Pressure Levels (dB re 1 µPa)	Frequency	Reference
General vessel operations	145-175 dB rms at 1 m	10 Hz – 1,500 Hz	Richardson et al. 1995a; Blackwell and Greene 2003; Ireland et al. 2016
General aircraft operations	100-124 dB rms at 1 m	<500 Hz	Richardson et al. 1995a
Rock laying for causeway	Less than dredging: 136-141 dB rms at 12-19 m	<500 Hz	Nedwell and Edwards 2004; URS 2007
Impact pile driving (12-60-inch pipe pile)	185-210 dB peak at 10 m 160-185 SEL at 10 m 170-195 rms at 10 m	<100-1,500 Hz	Illinworth & Rodkin 2007
Vibratory pile driving (12-72-inch pipe and sheet pile)	165-195 dB peak at 10 m 150-180 dB SEL at 10 m 150-180 dB rms at 10 m	<100-2,500 Hz	Illinworth & Rodkin 2007

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 decibels referenced to dB re 1 µPa-m (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 m; vibratory pile driving generally has energy up to 10 kHz, but produces lower peak levels ranging 165 to 195 dB re 1 µPa at 10 m (Illinworth 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. 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.

Vessel Operations

Vessels are major contributors to the overall acoustic environment (Richardson et al. 1995a), particularly in Alaska (Huntington et al. 2015). 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 m in the 6 to 500 Hertz (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 m at 2,000 Hz to 174.5 dB re 1 µPa rms at 1 m 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 m, while the docked cargo freight ship,

Northern Lights, produced the lowest broadband levels of 126 dB re 1 µPa at 100-400 m. Ship noise was generally below 1 kHz.

Aircraft Operations

Helicopters and fixed-wing aircraft generate noise from their engines, airframe, and propellers. Aircraft operations at the Amakdedori port would be associated with construction of the port access road to the south ferry terminal. Once construction of the port access road is complete, the amount of aircraft landing at Amakdedori port would be anticipated to be greatly reduced. The dominant tones for both types of aircraft 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 for a Bell 212 helicopter, 101 dB re 1 µPa for a small fixed-wing aircraft, 107 dB re 1 µPa for a twin otter, and 124 dB re 1 µPa for a P-3 Orion.

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 3 meters depth, and 11 seconds at 18 meters 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 Variants at the Amakdedori port site under Alternative 1 and the Diamond Point port site under Alternative 2. Illinworth and Rodkin (2007) compiled measured near-source (i.e., 10 meter) SPL data from impact pile driving for pile sizes ranging in diameter from 12 to 96 inches (Table K4.25-2). Non-impulsive underwater sound generated by construction activities has the potential to harass marine mammals where it exceeds 120 dB re µ1 Pa (rms) for NMFS species and 160 dB re 1 µ Pa (rms) for sea otters. Vibratory pile driving generally results in lower source sound levels, but the harassment threshold is larger than for impulsive sounds. Illinworth and Rodkin (2007) also compiled measured near-source (i.e., 10 meter) SPL data from impact 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.

K4.25.1.4 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) area of ensonification (square kilometers), which is determined by calculating the distance from

the source to the threshold, 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 will be used to calculate the appropriate number of potential marine mammal exposures. Calculated distances to agency thresholds are also used to establish mitigation and monitoring zones.