

Public

ALASKA LNG

Petition for Incidental Take Regulations for Construction of the Alaska LNG Project in Cook Inlet, Alaska

February 20, 2018

AKLNG-6010-REG-GRD-DOC-00001

Alaska LNG
3201 C Street, Suite 200
Anchorage, Alaska 99503
T: 907-330-6300
www.alaska-lng.com

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet,	Revision: 3
	Alaska	February 20, 2018
	Public	Page 2

- Page Intentionally Left Blank

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 3

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS	7
1. ACTIVITIES POTENTIALLY RESULTING IN MARINE MAMMAL EXPOSURES	9
1.1. Introduction	9
1.2. Proposed Alaska LNG Project Facilities Under This Petition.....	13
1.2.1. Marine Terminal.....	13
1.2.2. Mainline Material Offloading Facility.....	21
1.2.3. Mainline Crossing of Cook Inlet.....	22
2. DATES, DURATION, AND GEOGRAPHICAL REGION OF ACTIVITIES.....	28
2.1. Region of Activities	28
2.2. Dates and Duration of Activities	28
3. TYPE AND ABUNDANCE OF MARINE MAMMALS IN PROJECT AREA.....	29
3.1. Species and Number in the Project Area	29
4. DESCRIPTION OF MARINE MAMMALS IN COOK INLET PROJECT AREA	30
4.1. Humpback Whale.....	30
4.2. Beluga Whale	30
4.3. Killer Whale.....	34
4.4. Harbor Porpoise	34
4.5. Harbor Seal.....	35
5. REQUESTED TYPE OF INCIDENTAL TAKING AUTHORIZATION	35
6. NUMBER OF INCIDENTAL TAKES BY ACTIVITIES.....	35
6.1. Regulatory Acoustic Criteria	35
6.2. Description of Underwater Sound Sources.....	36
6.2.1. Dredging and Trenching	37
6.2.2. Impact Pile Driving	37
6.2.3. Vibratory Pile Driving	38
6.2.4. Vessel Sounds Associated with Construction Activities	38
6.3. Estimating Potential Marine Mammal Exposures	39
6.3.1. Level A Ensonification Area	39
6.3.2. Level B Ensonification Area	42
6.3.3. Duration of Sound per Activity.....	43
6.3.4. Marine Mammal Densities.....	46
6.4. Calculation of Potential Unmitigated Acoustic Exposures.....	48
6.4.1. Summary of Requested Takes.....	50
7. DESCRIPTION OF IMPACT ON MARINE MAMMALS.....	50
7.1. General Effects of Sound on Marine Mammals.....	50
7.2. Potential Effects of Sounds on Marine Mammals	51

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 4

7.2.1.	Tolerance.....	51
7.2.2.	Temporary Threshold Shift and Permanent Threshold Shift	52
7.2.3.	Hearing Impairment and Other Physical Effects	52
7.2.4.	Masking	53
7.3.	Behavioral Response of Marine Mammals	54
7.3.1.	Baleen Whales.....	54
7.3.2.	Toothed Whales	54
7.3.3.	Pinnipeds.....	56
7.3.4.	Stress and Mortality	57
8.	DESCRIPTION OF IMPACT ON SUBSISTENCE USES.....	58
8.1.	Subsistence Uses.....	58
8.1.1.	Beluga Whale	58
8.1.2.	Steller Sea Lion and Harbor Seal	59
8.1.3.	Other Marine Mammals.....	60
8.2.	Potential Impacts on Availability for Subsistence Uses	60
9.	DESCRIPTION OF IMPACT ON MARINE MAMMAL HABITAT	61
9.1.	Potential Physical Impacts on Habitat	61
9.1.1.	Seafloor Disturbance	61
9.1.2.	Water Quality Disturbance.....	63
9.2.	Potential Impacts on Food Sources from Sound Generation	64
9.2.1.	Zooplankton	64
9.2.2.	Benthos	65
9.2.3.	Fish	65
9.3.	Invasive Species	67
9.4.	Potential Impacts from Habitat Contamination	67
9.4.1.	Petroleum Release	67
9.4.2.	Contamination and Waste	67
10.	DESCRIPTION OF IMPACT FROM LOSS OR MODIFICATION TO HABITAT.....	68
10.1.	Beluga Whale Habitat	69
10.1.1.	Intertidal and Subtidal Waters of Cook Inlet.....	69
10.1.2.	Primary Prey Species	69
10.1.3.	Toxins or Other Agents Harmful to Beluga Whales	70
10.1.4.	Unrestricted Passage Within or Between Critical Habitat Areas	70
10.1.5.	In-Water Noise at Levels and Cook Inlet Beluga Whale Habitat	70
11.	MEASURES TO REDUCE IMPACTS TO MARINE MAMMALS	71
11.1.	Mitigation Measures.....	71
11.1.1.	Protected Species Observers.....	72
12.	MEASURES TO REDUCE IMPACTS TO SUBSISTENCE USERS	73

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 5

13. MONITORING AND REPORTING	74
13.1. Sound Source Verification.....	74
13.2. Protected Species Observations	74
13.3. Reporting.....	75
14. RESEARCH COORDINATION.....	76
15. REFERENCES	76

List of Tables

Table 1: Cook Inlet Seafloor Affected by Construction of the PLF	17
Table 2: Pile Structures to be Installed for the PLF in Season 2	18
Table 3: Pile Structures to be Installed for the PLF in Season 3	18
Table 4: Pile Structures to be Installed for the PLF in Season 4	18
Table 5: Cook Inlet Seafloor Affected by Construction of the MOF	19
Table 6: Cook Inlet Seafloor Directly Affected by the Cook Inlet Crossing	23
Table 7: Acoustical Characteristics of Planned Geophysical and Geotechnical Equipment	24
Table 8: Expected Volumes to be Excavated from Subsea Pipe Trenches in Cook Inlet.....	26
Table 9: Expected Seafloor Area Directly Affected by Trenching for Cook Inlet Crossing	26
Table 10: Anchors to be Handled during Installation of the Offshore Portion of Mainline Crossing ..	28
Table 11: Project Schedule	29
Table 12: Cetaceans and Pinnipeds in the Cook Inlet Project Area	30
Table 13: Marine Mammal Injury and Disturbance Thresholds for Underwater Sound.....	36
Table 14: Representative Underwater Sound Levels from Other Proposed Activities	37
Table 15: Near-Source Sound Pressure Levels from Impact Pile Driving	38
Table 16: Near-Source Sound Pressure Levels from Vibratory Pile Driving	38
Table 17: Calculated Distances in Meters to NOAA Fisheries Level A Thresholds	41
Table 18: Calculated Distances to NOAA Fisheries Level B Thresholds.....	43
Table 19: Calculation of Duration of Pile Driving in Total Days for Each Facility and Season	44
Table 20: Calculation of Duration of Anchor Handling in Total Days for Each Season.....	46
Table 21: Raw and Corrected Marine Mammal Density Estimates for Cook Inlet.....	47
Table 22: Summary of Unmitigated Number of Marine Mammals Exposed to Level A and Level B Thresholds Per Season and Per Facility	49
Table 23: Requested Annual Take Authorizations	50
Table 24: Marine Mammal Harvest by Tyonek in 2013 and Nikiski, Port Graham, Seldovia, and Nanwalek in 2014	58
Table 25: Steller Sea Lion and Harbor Seal Harvest by Tyonek in 2013 and Nikiski, Port Graham, Seldovia and Nanwalek Communities in 2014	59
Table 26: Seafloor Disturbance from Construction of the Marine Terminal and Mainline Crossing...	62
Table 27: Benthic Infaunal Sampling Results Near Proposed Marine Terminal.....	63
Table 28: Guidelines for Assessing Acoustical Impacts to Fish from Pile Driving.....	66

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 6

List of Figures

Figure 1: Project Overview 11

Figure 2: Petition Geographic Area 12

Figure 3: Location of Proposed Project Marine Terminal 14

Figure 4: Product Loading Facility and Material Offloading Facility..... 15

Figure 5: Berth Layout – Plain View..... 16

Figure 6: General Arrangement of the Temporary Material Offloading Facility..... 21

Figure 7: Mainline Crossing of Cook Inlet..... 25

Figure 8: Cook Inlet Beluga Whale Range and Critical Habitat 33

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 7

ACRONYMS AND ABBREVIATIONS

μPa	microPascal
ADEC.....	Alaska Department of Conservation
ADF&G.....	Alaska Department of Fish and Game
AGDC	Alaska Gasline Development Corporation
APDES.....	Alaska Pollutant Discharge Elimination System
AHT.....	anchor handling tug
BA	Biological Assessment
BIOp.....	Biological Opinion
CFR	Code of Federal Regulations
dB	decibel
dB re 1 μPa	decibel referenced to one microPascal
DPS	Distinct Population Segment
EIS.....	Environmental Impact Statement
ER	Environmental Report
ESA	Endangered Species Act
EZ.....	Exclusion Zone
FERC	Federal Energy Regulatory Commission
FR	Federal Register
IHA.....	Incidental Harassment Authorization
ITR	Incidental Take Regulation
kHz.....	kilohertz
km	kilometers
LNG.....	liquefied natural gas
LNGC.....	liquefied natural gas carrier
Lo-Lo.....	lift-on/lift-off
LOA.....	Letter of Authorization
L _{pk}	peak level
MHHW.....	mean higher high water
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MOF.....	Material Offloading Facility
MP	milepost
MTRP	Marine Terminal Redevelopment Project
NEPA.....	National Environmental Policy Act
NGA	Natural Gas Act
NMFS.....	National Marine Fisheries Service
NOAA.....	National Oceanic and Atmospheric Administration
North Slope	Alaska North Slope
NTU	nephelometric turbidity unit

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet,	Revision: 3
	Alaska	February 20, 2018
	Public	Page 8

PBU.....Prudhoe Bay Unit
 PCEPrimary Constituent Element
 PLF.....Product Loading Facility
 ppmparts per million
 PSOprotected species observer
 PTS.....permanent threshold shift
 PTU.....Point Thomson Unit
 Rradius
 rmsroot mean square
 Ro-Ro.....roll-on/roll-off
 rpm.....rotations per minute
 SEL.....sound exposure limit
 SPCCSpill Prevention, Control, and Countermeasure
 SPL.....sound pressure level
 SSV.....sound source verification
 SZ.....Safety Zone
 TL.....transmission loss
 TS.....threshold shift
 TTS.....temporary threshold shift
 USACE.....United States Army Corps of Engineers
 USCGUnited States Coast Guard
 USFWS.....United States Fish and Wildlife Service
 WFA.....weighting factor adjustment

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 9

1. ACTIVITIES POTENTIALLY RESULTING IN MARINE MAMMAL EXPOSURES

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

1.1. Introduction

National Oceanic and Atmospheric Administration (NOAA) Fisheries administers regulations governing the issuance of Incidental Harassment Authorizations (IHAs) and Letters of Authorization (LOAs) through promulgation of Incidental Take Regulations (ITRs) permitting the incidental, but not intentional, take of marine mammals under certain circumstances. The regulations 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” (50 CFR 216.316).

The Alaska Gasline Development Corporation (AGDC) (Applicant) plans to construct one integrated liquefied natural gas (LNG) Project (Project) with interdependent facilities for liquefying supplies of natural gas from Alaska, from the Point Thomson Unit (PTU) and Prudhoe Bay Unit (PBU) production fields on the Alaskan North Slope (North Slope), for export in foreign commerce and for in-state deliveries of natural gas. The Project includes a Liquefaction Facility on the Kenai Peninsula. The location of the Project is depicted in Figure 1.

AGDC is petitioning NOAA Fisheries to promulgate ITRs pursuant to Section 101(a)(5)(D) of the MMPA to allow non-lethal takes of whales and seals incidental to the first five years of Project construction in marine waters of Cook Inlet. This petition addresses and requests coverage for only those Project activities that are associated with the construction of the Project within Cook Inlet (see Figure 2) and that could have direct or indirect effects on marine mammal species managed by NOAA Fisheries. These Project activities are:

- Construction of the proposed Marine Terminal in Cook Inlet, including construction of a temporary Material Offloading Facility (MOF) and a permanent Product Loading Facility (PLF).
- Construction of the Mainline across Cook Inlet, including the potential construction of a Mainline MOF on the west side of Cook Inlet.

Components of proposed construction activities in Cook Inlet that have the potential to result in acoustical exposures that rise to the level of takes of marine mammals include:

- Vibratory and impact pile driving associated with MOF and PLF construction.
- Anchor handling associated with pipelay across the Cook Inlet.

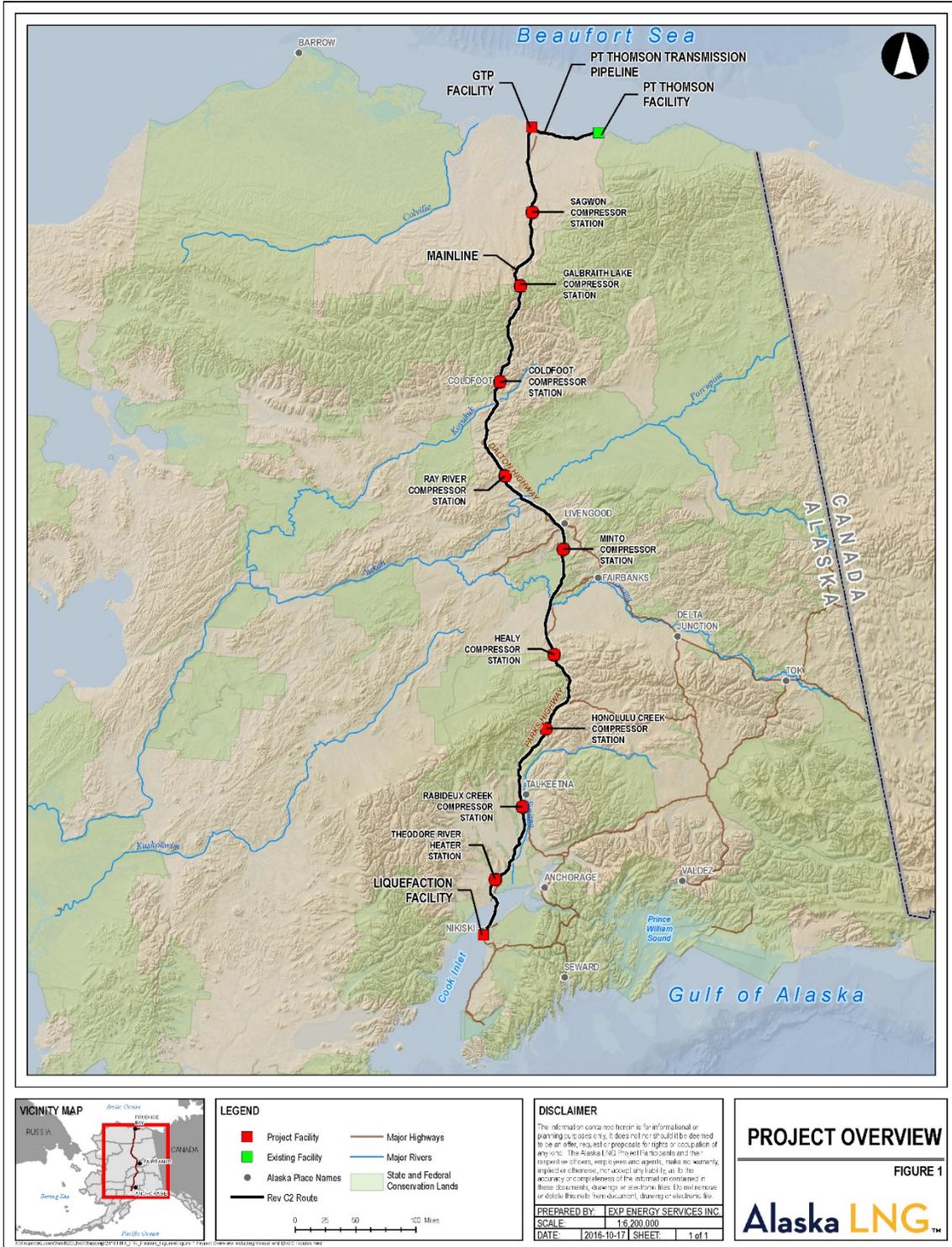
With implementation of the mitigation and monitoring measures described in Sections 11 and 13, no takes by injury or mortality (Level A) are anticipated, and a small number of takes by disturbance (Level B) are expected.

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet,	Revision: 3
	Alaska	February 20, 2018
	Public	Page 10

Section 216.104 of the MMPA sets out 14 specific items that must be addressed in requests for ITRs pursuant to Section 101(a)(5) of the MMPA. The 14 items are addressed in Sections 1 through 14 of this petition.

An application has been submitted to the Federal Energy Regulatory Commission (FERC) for authorization of the Project under the Section 3 of the Natural Gas Act (NGA). A full description of the Project is provided in Resource Report No. 1 within the Environmental Report (ER) submitted with the application. An Environmental Impact Statement (EIS) is being prepared, with FERC as the lead agency, as part of the regulatory review under the National Environmental Policy Act (NEPA). This EIS will include the activities described in the ER as well as this petition. FERC is also the lead agency for Section 7 consultation with NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA) for authorization of the Project under the NGA. A draft Applicant-prepared Biological Assessment (BA) has been prepared as part of this consultation effort, and can be viewed as Appendix C to Resource Report No. 3 in the FERC application. FERC will finalize the BA in consultation with NOAA Fisheries and the USFWS in the course of the development of the Draft EIS.

Figure 1: Project Overview



ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 13

1.2. Proposed Alaska LNG Project Facilities Under This Petition

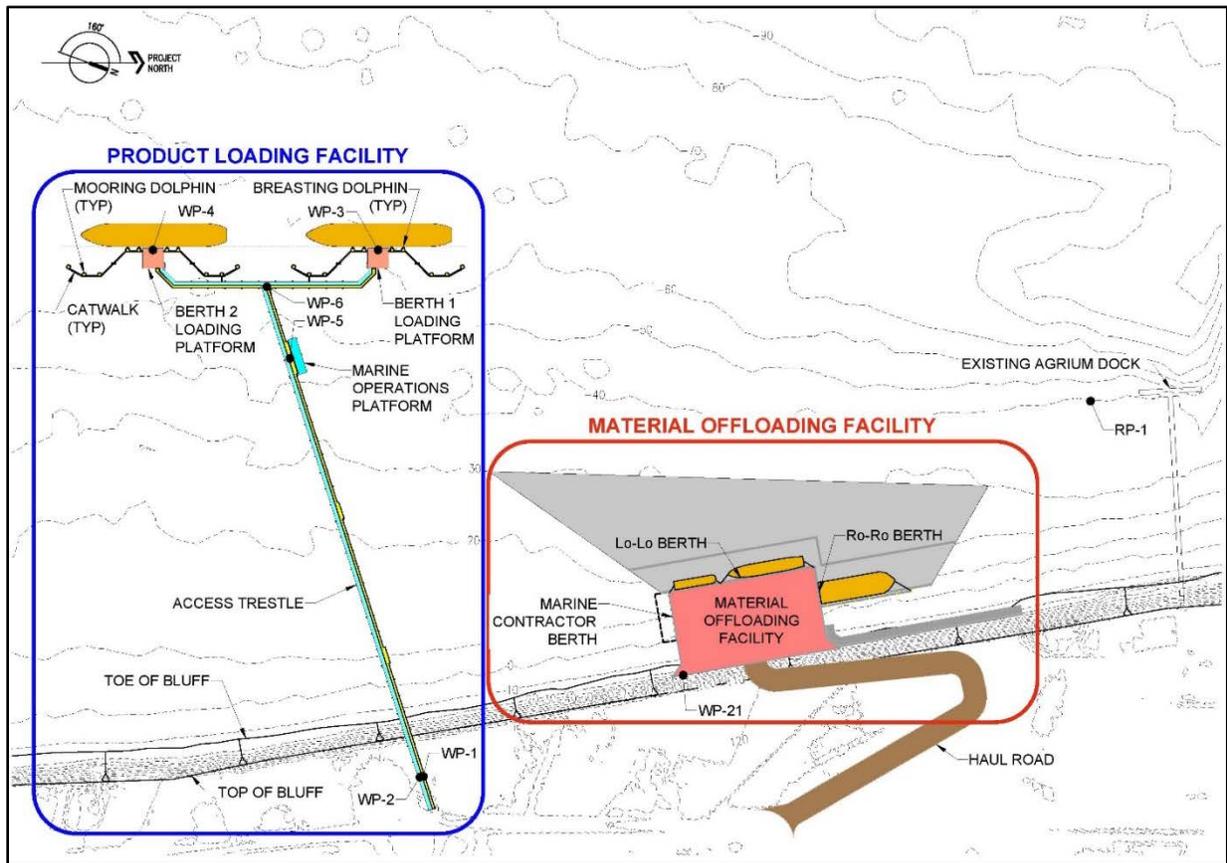
In this document, the Applicant petitions NOAA Fisheries for ITRs that would cover planned activities associated with construction of the Project’s proposed facilities in Cook Inlet, which include a Marine Terminal and the Mainline crossing of Cook Inlet. The Marine Terminal consists of a permanent PLF and a temporary MOF. The Mainline crossing includes the installation of the 42-inch-diameter natural gas pipeline across the inlet, and construction of a Mainline MOF. Brief descriptions of these proposed facilities are provided below. This petition asks for coverage of activities associated with construction of these facilities that are expected to generate underwater sound energy at levels that NOAA Fisheries has deemed sufficient to potentially result in Level B harassment of marine mammals. As detailed in Section 6 of this petition, those activities have been identified as pile driving associated with construction of the PLF, Temporary MOF, and Mainline MOF, and anchor handling associated with installation of the Mainline crossing of Cook Inlet. Descriptions of construction of the facilities is therefore focused on these specific activities. The Applicant may perform a sound source verification (SSV) at the beginning of the pile driving to characterize the sound levels associated with different pile and hammer types, as well as to establish the marine mammal monitoring and mitigation zones.

1.2.1. Marine Terminal

The proposed Marine Terminal would be constructed adjacent to the proposed onshore LNG Plant near Nikiski, Alaska, (Figure 2) and would allow LNG carriers (LNGCs) to dock and be loaded with LNG for export (Figure 3). Primary components of the Marine Terminal include a PLF and the Temporary MOF (Figure 4).

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 15

Figure 4: Product Loading Facility and Material Offloading Facility



1.2.1.1. Product Loading Facility

The proposed PLF would be a permanent facility used to load LNGCs for export. It consists of two loading platforms, two berths, a Marine Operations Platform, and an access trestle that supports the piping that delivers LNG from shore to LNGCs and include all the equipment to dock LNGCs. Analyzed elements of the PLF are shown in Figures 3 and 4 and are described as follows.

- **PLF Loading Platforms** – Two loading platforms, one located at either end of the north-south portion of the trestle (Figure 4), would support the loading arm package, a gangway, and supporting piping, cabling, and equipment. The platforms would be supported above the seafloor on steel-jacketed structures called quadpods.
- **PLF Berths** – Two berths would be located in natural water depths greater than -53 feet mean lower low water (MLLW) and would be approximately 1,600 feet apart at opposite ends of the north-south portion of the trestle.

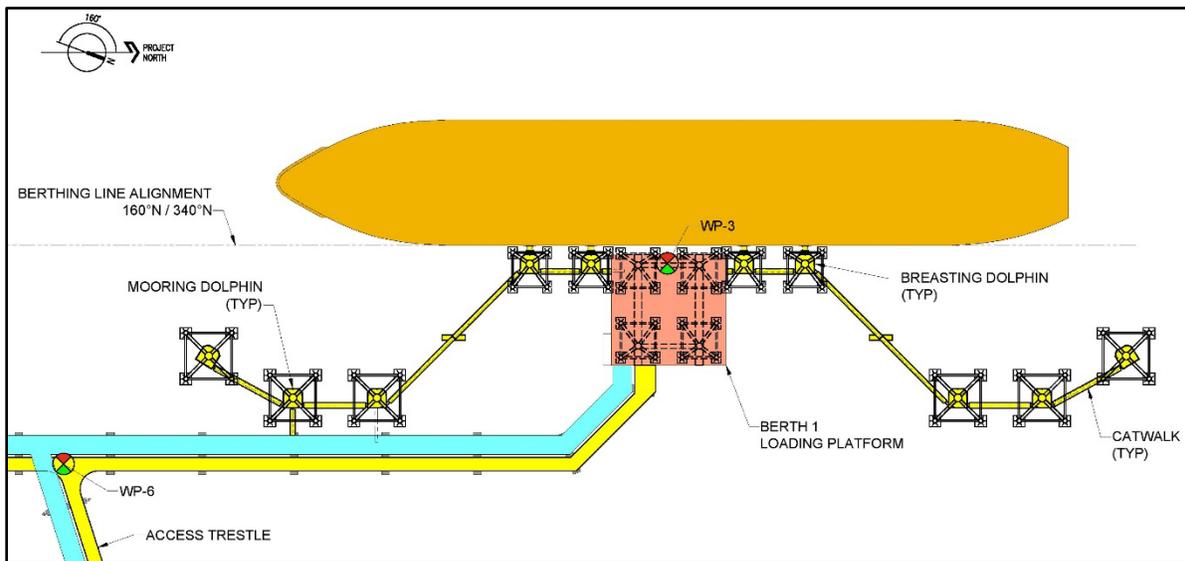
Each berth would have four concrete pre-cast breasting dolphins and six concrete pre-cast mooring dolphins (Figure 5). The mooring and breasting dolphins would be used to secure vessels alongside the berth for cargo loading operations. The mooring and breasting dolphins would be supported over

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 16

the seabed on quadropods. A catwalk, supported on two-pile bents, would connect the mooring dolphins to the loading platforms.

- **Marine Operations Platform** – A Marine Operations Platform would be located along the east-west portion of the access trestle (Figure 4), and would support the proposed Marine Terminal Building; an electrical substation, and piping, cabling, and other equipment used to monitor the loading operations. The platform would be supported above the seafloor on four-pile bents.
- **Access Trestle** – This structure is T-shaped with a long east-west oriented section and a shorter north-south oriented section, and carries pipe rack, roadway, and walkway. The pipe rack contains LNG loading system pipelines, a fire water pipeline, utility lines, power and instrument cables, and lighting. The east-west portion of the trestle extends from shore, seaward, for a distance of approximately 3,650 feet, and would be supported on three-pile and four-pile bents at 120-foot intervals. The north-south oriented portion of the access trestle is approximately 1,560 feet long, and is supported on five-pile quadropods.

Figure 5: Berth Layout – Plain View



Construction of the Product Loading Platforms and Berths

Construction methods would be both overhead (conducted with equipment located on a cantilever bridge extending from shore) construction and marine (conducted with equipment located on barges/vessel) construction. Seafloor that would be directly affected by construction of the PLF is itemized in Table 1.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 17

Table 1: Cook Inlet Seafloor Affected by Construction of the PLF

Facility/Activity	Affected during Construction (acres)
PLF	18.67 ¹
Total	18.67 ¹

¹ The acreage represents the seafloor under the PLF; a much smaller footprint of disturbance within this area would actually be impacted by the bents and quadropods supporting the PLF on the seafloor.

The PLF would be constructed using both overhead and marine construction methods. As planned, the PLF would be constructed over the course of four ice-free seasons (Seasons 1–4); however, Season 1 activities associated with PLF construction include only installation of onshore portions of the PLF, and are therefore not described or analyzed in this petition. Activities in Seasons 2 through 4 are described below. Each season extends from 1 April through 31 October, during which construction crews would be working 12 hours per day, six days per week.

In Season 2, the marine construction spread would be mobilized and the cantilever bridge would be commissioned. A total of 35 bents and quadropod structures would be installed for part of the east-west access trestle, and eight quadropods would be installed to support the berth loading platforms.

In Season 3, the remainder of the bents for the east-west access trestle would be installed. Additionally, bents supporting the Marine Operations Platform and north-south trestle would be installed. A total of 26 bent and quadropod structures would be installed.

In Season 4, installation of the mooring quadropods would be completed, and the bents supporting the catwalk between the loadout platforms and the mooring dolphins would be installed. A total of 18 bent and quadropod structures would be installed.

The numbers and types of piles that would be installed in Seasons 2–4 are listed in Table 2, Table 3, and Table 4. All PLF bents and quadropods are expected to be installed with impact hammers. The anticipated production rate for installation of the bents is one bent per six construction days, and for quadropods it is one quadropod per eight work days. Pile driving is expected to occur during only two of the six days for bents and two of the eight days for quadropods. It is also assumed the impact hammer would only be operated approximately 25 percent of time during the two days of pile driving.

Table 2: Pile Structures to be Installed for the PLF in Season 2

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ⁴	Months
			48-inch Piles	60-inch Piles				
E-W Trestle	3-pile bent ¹	11	-	33	Impact ²	overhead	22	April–June
E-W Trestle	4-pile bent	10	-	40	Impact ³	marine	20	June–August
Berth 1	quadropod	4	20	-	Impact ³	marine	8	April–May
Berth 2	quadropod	4	20	-	Impact ³	marine	8	April–May
N-S Trestle	quadropod	8	40	-	Impact ³	marine	16	May–June
Total	--	35	80	63	--	--	74	April–June

¹ Four three-pile bents for the E-W (east-west) access trestle would be installed in Season 2; however, two of them are onshore and two are in the intertidal and would be installed when the tide is out.

² Two impact hammers are expected to be used from the barges.

³ One impact hammer is expected to be used from the overhead cantilever bridge.

⁴ Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure, pile driving would occur during only a portion of each day.

Table 3: Pile Structures to be Installed for the PLF in Season 3

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ³	Month(s)
			48-inch	60-inch				
E-W Trestle	4-pile bent	7	-	28	Impact ¹	overhead	14	April–May
Operations Platform	4-pile bent	3	-	12	Impact ¹	overhead	6	May–June
Breasting Dolphins	quadropod	8	8	32	Impact ²	marine	16	April–May
Mooring Dolphin	quadropod	2	2	8	Impact ²	marine	4	May
N-S Trestle	quadropod	6	30	-	Impact ²	marine	12	April–May
Total	--	26	40	80	--	--	52	April–June

¹ Three impact hammers are expected to be used from the barges.

² One impact hammer is expected to be used from the overhead cantilever bridge.

³ Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure, pile driving would occur during only a portion of each day.

Table 4: Pile Structures to be Installed for the PLF in Season 4

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ²	Month(s)
			48-inch	60-inch				
Mooring Dolphin	quadropod	10	10	40	Impact ¹	marine	20	April–June
Catwalk	2-pile bent	4	-	8	Impact ¹	marine	16	April–May
Total	--	18	10	48	--	--	36	April–June

¹ Two impact hammers are expected to be used from the barges.

² Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure, pile driving would occur during only a portion of each day.

1.2.1.2. Temporary Material Offloading Facility

The proposed Temporary MOF, to be located near the PLF in Nikiski (Figures 2-4), would consist of three berths and a quay (Figure 6) that would be used during construction of the Liquefaction Facility to enable direct deliveries of equipment modules, bulk materials, construction equipment, and other cargo to minimize the transport of large and heavy loads over road infrastructure.

The MOF quay would be approximately 1,050 feet long and 600 feet wide, which would provide sufficient space for cargo discharge operations and accommodate 200,000 square feet of staging area. It would have a general dock elevation of +32 feet MLLW.

The quay would have of an outer wall consisting of combi-wall (combination of sheet piles and pipe piles) tied back to a sheet pile anchor wall, and 11 sheet pile coffer cells, backfilled with granular materials.

Berths at the MOF would include:

- One Lift-on/Lift-off (Lo-Lo) berth with a maintained depth alongside of -32 feet MLLW.
- One Roll-on/Roll-off (Ro-Ro) berth with a maintained depth alongside of -32 feet MLLW.
- One grounded barge bed with a ground pad elevation of +10 feet MLLW.

The MOF has been designed as a temporary facility, and would be removed early in operations when it is no longer needed to support construction of the Liquefaction Facility.

Seafloor areas directly affected by construction of the MOF and the associated dredging are itemized in Table 5.

Table 5: Cook Inlet Seafloor Affected by Construction of the MOF

Facility/Activity	Affected during Construction (acres)
Temporary MOF	^a 28.30
Temporary MOF dredging area	50.70
Dredge disposal area	1,200.00
Shoreline protection	1.54
Total	1,263.55

^a The temporary MOF footprint and temporary MOF dredging area overlap by 16.98 acres. This acreage was removed from the total avoid double-counting the impact and arrive at the displayed total.

Construction of the Temporary MOF

The Temporary MOF would be constructed over the course of two construction seasons (Seasons 1 and 2), with each season extending from 1 April through 31 October. The number of sheet pile and pipe pile structures that would be installed in each season, along with the methods and durations of the installation activities, are provided in Table 6.

The combi-wall and the first six of eleven coffer cells would be installed in Season 1. An equal amount of sheet pile anchor wall would be associated with the combi-wall, but this is not considered in the analysis or requested takes, as the anchor wall would be driven into fill and would not generate substantial

underwater sound. Six 24-inch template pipe piles would be installed with a vibratory hammer before the sheet pile is installed for each coffer cell and then removed when coffer cell installation is complete. The remaining five coffer cells and fill would be installed in Season 2, along with the quadropods for the dolphins for the RoRo berth.

The Temporary MOF would be constructed using both land-based (from shore and subsequently from constructed portions of the MOF) and marine construction methods. Crews are expected to work 12 hours per day, six days per week. The anticipated production rate for installation of combi-wall and coffer cells is 25 linear feet per day per crew, with two crews operating, and vibratory hammers operating 40 percent of each 12-hour construction day. The anticipated production rate for quadropod installation is the same as described in Section 1, above.

Table 6: Sheet and Pile Structures to be Installed as Part of Temporary MOF Construction

Season	Structure Type	Number of Structures	Number of Piles			Sheet Pile (feet)	Method	Hammer	Days ^a	Months
			24-inch	48-inch	60-inch					
1	combi-wall ^b	1	-	-	35	1,075	land	vibratory	21.5	Jul
1	coffer cell	6	36 ^c	-	-	2,454	land	vibratory	55.1	Jul-Oct
2	coffer cell	5	30 ^c	-	-	2,447	land	vibratory	53.9	Apr-Jun
2	quadropod ^d	7	28	7	-	-	marine	impact	14	Apr-Jun
All	-	19	94	7	35		-	-	132.5	Apr-Oct

^a Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure for pile driving, 25 feet per day per crew for sheet pile and combi-wall. Pile driving would occur during only a portion of each of these days.

^b Combi-wall is a wall made of sheet piles with pipe piles at interval along the wall for support; there would also be an equal length of anchor wall with no pipe piles installed in fill (no underwater sound).

^c These are 24-inch piles or spuds driven in the seafloor to form templates for the circular sheet pile.

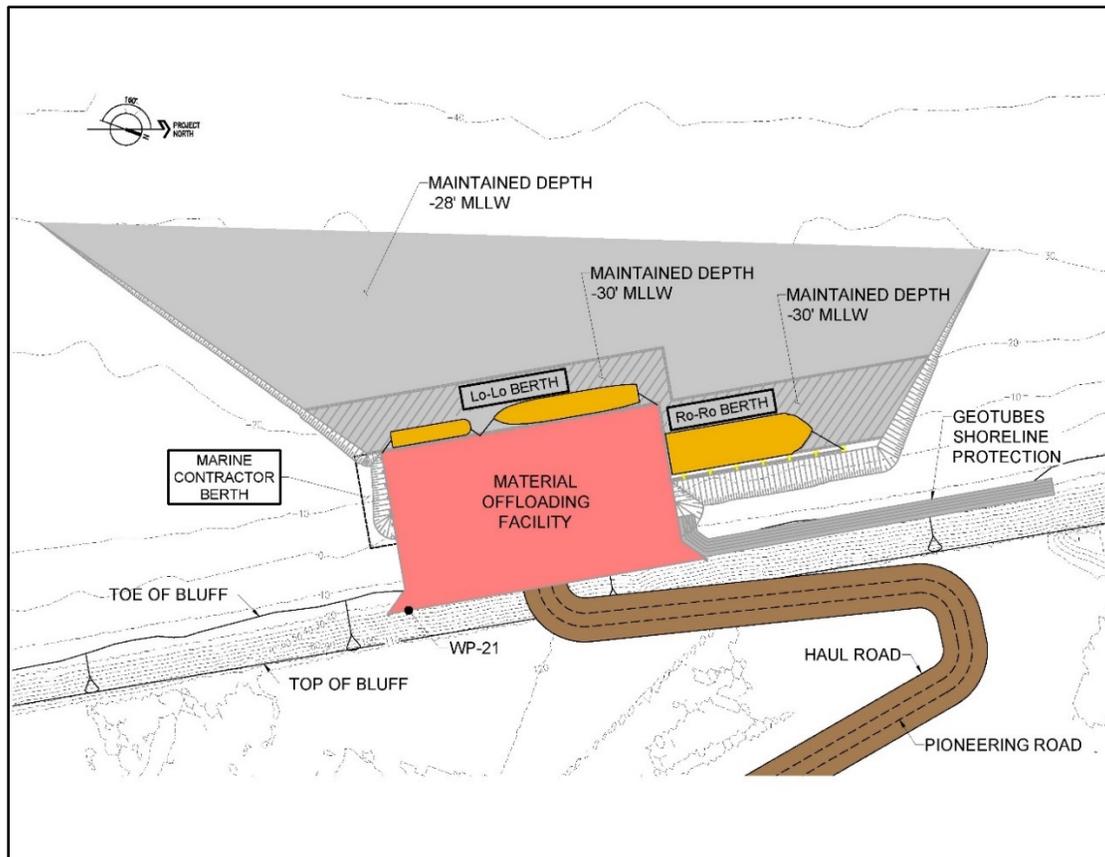
^d Five-pile quadropods for the MOF RoRo dolphins

Dredging would be conducted over two ice free seasons. Dredging at the MOF during the first season of marine construction may be conducted with either an excavator or clamshell (both mechanical dredges). Various bucket sizes may be used. Sediment removed would be placed in split hull or scow/hopper barges tended by tugs that would transport the material to the location of dredge material placement.

Dredging at the MOF during the second season may be conducted with either a hydraulic (cutter head) dredger or a mechanical dredger. For a hydraulic dredger, the dredged material would be pumped from the dredge area to the disposal location or pumped into split-hull barges for transport to the placement location. If split-hull barges are used rather than direct piping of material, a manifold system may be set up to load multiple barges simultaneously. For a mechanical dredger, two or more sets of equipment would likely be required to achieve total dredging production to meet the Project schedule. Personnel transfer, support equipment, and supply would be similar to the first season.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 21

Figure 6: General Arrangement of the Temporary Material Offloading Facility



1.2.2. Mainline Material Offloading Facility

A MOF may be required on the west side of Cook Inlet to support installation of the Cook Inlet shoreline crossing, and onshore construction between the South of Beluga Landing shoreline crossing and the Yentna River. The Mainline MOF would be located near, but at a reasonable distance, from the existing Beluga Landing. Use of the existing landing is not considered to be feasible.

The Mainline MOF would consist of a quay, space for tugs, and berths including:

- Lo-Lo Berth for unloading pipes and construction materials.
- Ro-Ro Berth and ramp dedicated to Ro-Ro operations.
- Fuel berth dedicated to unloading fuel.

The quay would be 450 feet long (along the shoreline) and 310 feet wide (extending into the Cook Inlet). A Ro-Ro ramp (approximately 80 feet by 120 feet) would be constructed adjacent to the quay. Both the quay and the Ro-Ro ramp would consist of anchored sheet pile walls backed by granular fill. The sources for the granular material would be onshore. Surfacing on the quay would be crushed rock. Some fill

material for the quay and Ro-Ro ramp are expected to be generated by excavation of the access road. Any additional needed fill materials and crushed rock for surfacing, would be barged in.

The quay and the Ro-Ro ramp are located within the 0-foot contour, so berths would be practically dry at low tide. No dredging is planned; vessels would access the berths and ground themselves during high tide cycles. The proposed top level of the Mainline MOF is +36 feet MLLW, which is about 11 feet above Mean Higher High Water (MHHW).

Construction of the Mainline MOF

Approximately 1,270 feet of sheet pile would be installed for construction of the quay and Ro-Ro ramp, and a corresponding length of sheet pile would be installed as anchor wall; however, only 670 feet of sheet pile would be installed in the waters of Cook Inlet. The remainder would be installed as anchor wall in fill material, or in the intertidal area when the tide is out, and would not result in underwater sound.

The Mainline MOF would be constructed in a single construction season (Season 1), which would extend from 1 April to 31 October. A break-down of activities per season is provided below. Crews are expected to work 12 hours per day, six days per week. The sheet pile would be installed using marine equipment, with the first 50 percent of embedment conducted using a vibratory hammer and the remaining 50 percent conducted using an impact hammer. Hammers would be expected to be operated either 25 percent of a 12-hour construction day (impact hammer) or 40 percent of a 12-hour construction day (vibratory hammer).

Table 7: Structures to be Installed in Cook Inlet as Part of Mainline MOF Construction

Season	Structure Type	Structures	Sheet Pile (feet)	Pipe Pile (number)	Hammer	Method	Days ^a	Months ^b
1	quay ^c	1	470	-	vibratory / impact ^e	marine	10	Apr-May
1	RoRo ramp ^c	1	200	-	vibratory / impact ^e	marine	4	Apr-May
All	-	2 ^c	670 ^d	-	vibratory / impact ^e	marine	14	Apr-May

^a Number of days on which pile-driving would occur based on expected progress rate of 25 linear feet per day per crew (2 crews) for sheet pile; however, pile driving would occur during only a portion of each of these days – approximately 40 percent of work day when operating vibratory hammer and 25 percent of work day with impact hammer.

^b Months during which some of the pile driving is expected to occur.

^c The quay and the RoRo ramp are adjoining parts of the Mainline MOF.).

^d Itemized sheet pile is for only sheet pile installed in the water; additional sheet pile would be installed in the dry (600 feet, in intertidal area when tide is out) and additional sheet pile installed in fill as anchor wall. These piles are not included in table or analyzed in the document as installation would not result in significant underwater sound.

^e The first 50 feet of embedment would be conducted with a vibratory hammer, and the remainder with an impact hammer – assume half of the pile driving days with each hammer type.

1.2.3. Mainline Crossing of Cook Inlet

The proposed Mainline, a 42-inch-diameter, natural gas pipeline, would cross the Cook Inlet shoreline on the west side of the inlet (north landfall) south of Beluga Landing at pipeline milepost (MP) 766.3, traverse

Cook Inlet in a generally southward direction for approximately 26.7 miles, and cross the east Cook Inlet shoreline near Suneva Lake at MP 793.1 (south landfall) (Figure 7). The pipe would be trenched into the seafloor and buried from the shoreline out to a water depth of approximately 35-45 feet MLLW on both sides of the inlet, approximately 8,800 feet from the north landfall and 6,600 feet from the south landfall. Burial depth (depth of top of pipe below the seafloor) in these areas would be 3–6 feet. Seaward of these sections, the concrete coated pipeline would be placed on the seafloor. Seafloor that would be directly affected by construction and operation of the Cook Inlet crossing of the Mainline is itemized in Table 6. Additional footprint would be impacted by the use of anchors to hold the pipelay vessel in place while installing the pipeline on the seafloor.

Table 6: Cook Inlet Seafloor Directly Affected by the Cook Inlet Crossing

Facility/Activity	Affected during Construction (acres) ¹
Nearshore trenching	15-29 acres / 6.1-11.7 hectares
Offshore pipe installation	11 acres / 4.5 hectares
Total	40 acres / 16.2 hectares

¹ Additional seafloor impacts would occur from anchoring of the pull barge and pipelay vessel.

Pre-installation Surveys

Geophysical surveys would be conducted just prior to pipeline construction. A detailed bathymetric profile (longitudinal and cross) would be conducted. Types of geophysical equipment expected to be used for the surveys would include (Table 7):

- Single-beam echosounder planned for use during this program operate at frequencies greater than 200 kilohertz (kHz).
- Multi-beam echo sounders planned for this program operate at frequencies greater than 200 kHz.
- Side-scan sonar system planned for use during this program operate at a frequency of 400 and 900 kHz.
- Magnetometer. These instruments do not emit sound.

Acoustic characteristics of equipment expected to be used are provided in Table 7. Operation of geophysical equipment such as echosounders and side-scan sonars at frequencies greater than 200 kHz are generally not considered to result in acoustic harassment of marine mammals. Magnetometers do not emit underwater sound. The geophysical surveys are therefore not evaluated further in this petition.

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet, Alaska	Revision: 3
	Public	February 20, 2018
		Page 24

Table 7: Acoustical Characteristics of Planned Geophysical and Geotechnical Equipment

Type	Model ¹	Operating Frequency (kHz)	Source Level ³ (dB re 1 μ Pa-m [rms])
Single beam echo sounder	Echotrac CV-100	>200 ²	146 ⁴
Multibeam echo sounder	Sonic 2024	>200 ²	188 ⁴
Side-scan sonar	EdgeTech 4125	400-1600 ²	188 ⁴

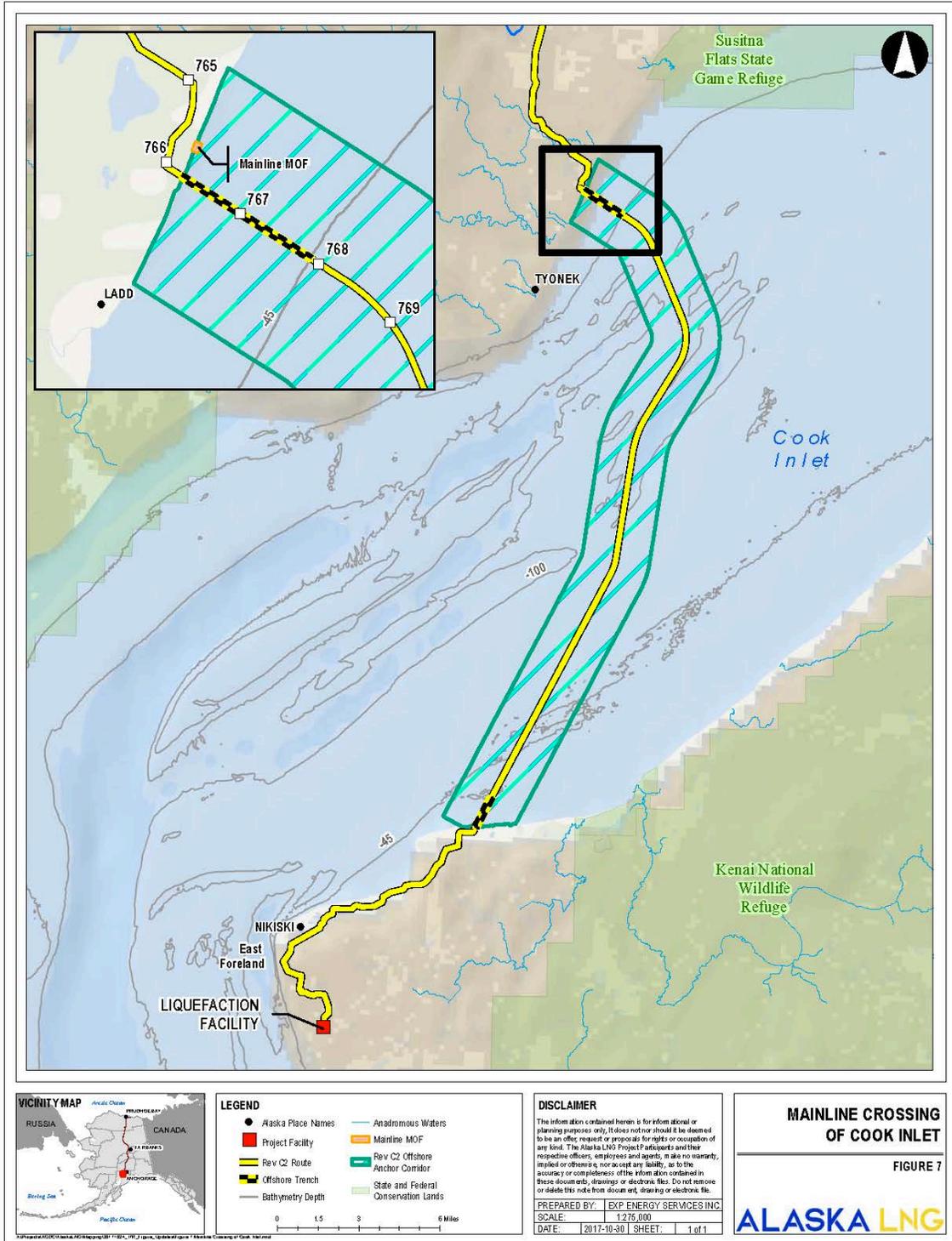
¹ A similar model may be used.

² Source: Manufacturer brochure.

³ rms = root mean square.

⁴ Shores 2013.

Figure 7: Mainline Crossing of Cook Inlet



Trenching, Pipelay, and Burial

The pipeline would be trenched and buried in the nearshore portions of the route across the Cook Inlet. Dimensions of these trenches are provided in Table 8 and Table 9.

Table 8: Expected Volumes to be Excavated from Subsea Pipe Trenches in Cook Inlet

Site	Subsea Trench Length		Overcut (feet)	Trench Slope (Depth: Width)	Subsea Trench Cross Sectional Area (square feet)	Seafloor Area Trenched	
	To -35 feet	To -45 feet				To -35 feet (cubic yards)	To -45 feet (cubic yards)
Beluga Landing	8,300	8,800	5	1:3	500	155,000	163,000
				1:6	900	274,000	289,000
Suneva Lake	6,400	6,600	5	1:3	500	118,000	123,000
				1:6	900	209,000	218,000

Table 9: Expected Seafloor Area Directly Affected by Trenching for Cook Inlet Crossing

Site	Subsea Trench Length		Trench Slope (Depth: Width)	Trench Width (feet)	Seafloor Area Trenched	
	To -35 feet	To -45 feet			To -35 feet (acres)	To -45 feet (acres)
Beluga Landing	8,300	8,800	1:3	76.5	15	15
			1:6	143.0	27	29
Suneva Lake	6,400	6,600	1:3	76.5	11	12
			1:6	143.0	21	22

The nearshore portion of the trench is expected to be constructed using amphibious or barge-based excavators. This portion of the trench would extend from the shoreline out to a transition water depth where a dredge vessel can be employed. On the west side of the inlet (Beluga Landing) this is expected to be from the shore out 655 feet, and on the east side (Suneva Lake) from the shoreline out 645 feet. The trench basis is to excavate a shallow slope trench that would not retain sediments (i.e., a self-cleaning trench). A backhoe dredge may also be required to work in this portion of the crossing.

From the transition water depth to water depths of the -35 feet or -45 feet MLLW, a trailing suction hopper dredger would be used to excavate a trench for the pipeline. Alternative burial techniques, such as plowing, backhoe dredging, or clamshell dredging, would be considered if conditions become problematic for the dredger. After installation of the nearshore pipelines, a jet sled or mechanical burial sled could be used to achieve post dredge burial depths.

Pipeline joints would be welded together onshore in 1,000-foot-long strings and laid on the ground surface in an orientation that approximates the offshore alignment. A pipe pull barge would be anchored offshore near the seaward end of the trench, and would then be used to pull the pipe strings from their onshore position, out into the trench.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 27

Following pipeline installation, the trench is expected to backfill naturally through the movement of seafloor sediments. If manual backfilling is required, the backfill would be placed by reversing the flow of the trailing suction hopper dredger used offshore (see below) or mechanically with the use of excavators.

Offshore Pipeline Installation

Seaward of the trenched sections, the pipeline would be laid on the seafloor across Cook Inlet using conventional pipelay vessel methods. The pipelay vessel would likely employ 12 anchors to keep it positioned during pipelay and provide resistance as it is winched ahead 80 feet each time an additional 80-foot section of pipe is added/welded on the pipe string. Dynamic positioning may be used in addition to the conventional mooring system. Mid-line buoys may be used on the anchor chains when crossing other subsea infrastructure (i.e., pipelines and cables). A pipelay rate of 2,000 to 2,500 feet per 24-hour period is expected. It is anticipated that three anchor handling attendant tugs would be used to repeatedly reposition the anchors, thereby maintaining proper position and permitting forward movement. The primary underwater sound sources of concern by NOAA Fisheries would be from the anchor handling tugs (AHTs) during the anchor handling for the pipelay vessel.

Construction Schedule for the Mainline Crossing

The pipeline crossing of Cook Inlet would be installed in two consecutive construction seasons (Seasons 3 and 4). The construction season extends from 1 April through 31 October. All work from the pipelay vessel and pull barge would be conducted 24 hours per day, seven days per week, until the work planned for that season is completed. Anchor handling durations were estimated differently for the two construction seasons. Anchor handling is expected to be conducted 25 percent of the time that the pull barge is on site in Season 3. The estimate for anchor handling duration in Season 4 was based on the proposed route length, the total numbers of individual anchors moves (Table 10), and the estimated time required to retrieve and reset each anchor (approximately 30 minutes per anchor to retrieve and reset). A breakdown of activities per season is provided below.

Season 3

- Conduct onshore enabling works including establishing winch/laydown and welding area, and excavation of a trench through onshore sections of the shore approach (open cut the shoreline).
- Excavate trench in very nearshore waters using land and amphibious excavation equipment.
- Conduct pre-lay excavation of the pipe trench out to depths of -35 to -45 feet MLLW using various subsea excavation methods.
- Install the pipe in the nearshore trenches using a pull barge.
 - Anchor handling would occur for approximately six (5.75 days) 24-hour periods in Season 3.
- Cap installed nearshore sections and leave in place until the next year.

Season 4

- Lay unburied offshore section of Mainline across Cook Inlet using conventional pipelay vessel.

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet,	Revision: 3
	Alaska	February 20, 2018
	Public	Page 28

- The Applicant estimates that anchor handling would occur over 13 24-hour periods in Season 4.
- Tie-in the offshore section to the buried nearshore sections on both sides of the Cook Inlet.
- Flood, hydrotest, and dry the Mainline pipeline with Cook Inlet.

Table 10: Anchors to be Handled during Installation of the Offshore Portion of Mainline Crossing

Season	Offshore Route (feet)	Lay Rate (feet/day)	Anchors Set
4	132,440	2,500	636

2. DATES, DURATION, AND GEOGRAPHICAL REGION OF ACTIVITIES

The dates and duration of such activity and the specific geographical region where it will occur.

2.1. Region of Activities

This petition requests coverage for Project activities within Cook Inlet north of Latitude 60° 30' (Figure 2). The activities would be conducted primarily at: the site of the proposed Marine Terminal (Figure 3); the site of the Mainline MOF (Figures 3 and 4); and the construction right-of-way for the Mainline crossing of Cook Inlet (Figure 7).

2.2. Dates and Duration of Activities

The Applicant intends to request that FERC issue authorization to construct the Project no later than late 2018, with construction to most likely commence late 2019. Construction activities would be divided into phases; the first phase is planned to last from 2019–2025 and would include construction of the marine facilities and Mainline. Table 11 summarizes the planned Project schedule for the Project activities located in the Cook Inlet basin. The Applicant requests that ITRs under this petition start 1 November 2019 and extend through October of 2024.

Table 11: Project Schedule

Major Milestone	Start Date	End Date
Application Submittal to FERC	--	2Q 2017
Anticipated Draft EIS	4Q 2017	4Q 2018
Anticipated Final EIS	4Q 2018	1Q 2019
Anticipated FERC Order	--	2Q 2019
Anticipated FERC Notices to Proceed for Construction Start	3Q 2019	1Q 2020
Marine Terminal		
Site Preparation Activities, MOF Construction	4Q 2019	2Q 2021
Dredging, Complete MOF	1Q 2021	2Q 2021
Commence Installation of Trestle and Berths, Quadropod Installation	1Q 2022	4Q 2022
Complete Installation of Trestle, Continue Installation of Berths, Commence Installation of PLF Modules, Berths, and Mooring Dolphins	1Q 2023	4Q 2023
Complete Installation of PLF	1Q 2024	4Q 2024
MOF Reclamation/Demobilization	3Q 2026	3Q 2027
Mainline Offshore Cook Inlet Spread		
Offshore Pipeline Construction	2Q 2022	1Q 2023
Hydrotest and Final Tie-In	2Q 2023	3Q 2023

The schedule for offshore construction activities is based on using the ice-free working windows (Season) in Cook Inlet, which extends approximately from April 1 through October 31. Season 1 is planned to commence in April 2020, Season 2 in April 2021, Season 3 in April 2022, Season 4 in April of 2023, and Season 5 in April 2024.

3. TYPE AND ABUNDANCE OF MARINE MAMMALS IN PROJECT AREA

<i>The species and numbers of marine mammals likely to be found within the activity area.</i>

3.1. Species and Number in the Project Area

The marine mammals most likely to be in the upper and mid-Cook Inlet activity area (Mainline crossing and Marine Terminal) are the Cook Inlet stock of beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), harbor seal (*Phoca vitulina*), and killer whale (*Orcinus orca*). Populations of these species become concentrated in Upper Cook Inlet during the summer months when they feed on runs of salmon (*Oncorhynchus* spp.) and eulachon (*Thaleichthys pacificus*) (Nemeth et al., 2007; Boveng et al., 2012). These species tend to move to mid and/or Lower Cook Inlet during winter as the Upper Inlet largely freezes over.

Other species that have recently been observed and more specifically, stranded in Cook Inlet include the humpback whale (*Megaptera novaeangliae*) (personal communication with Greg Balogh at NOAA Fisheries, 2016). There are rare occurrences of humpback whales in northern Cook Inlet where they have been sighted north of Nikiski (Lomac-MacNair et. al., 2014) however they are not expected to occur in Lower Cook Inlet as far north as the proposed Marine Terminal location near Nikiski or in Upper Cook Inlet near the Mainline crossing. The status and estimated stock size of marine mammals found in Cook Inlet are shown in Table 12.

Table 12: Cetaceans and Pinnipeds in the Cook Inlet Project Area

Species	Stock Estimate	Stock	ESA Status
Humpback Whale	10,103 ¹	Central North Pacific ²	-
Beluga Whale	328 ²	Cook Inlet	Endangered
Killer Whale	2,347 ¹	Alaska Resident	-
Killer Whale	587 ¹	Alaska Transient	-
Harbor Porpoise	31,046 ¹	Gulf of Alaska	-
Harbor Seal	27,386 ¹	Cook Inlet/Shelikof	-

¹ Muto et al. 2017

² Sheldon et al. 2017

4. DESCRIPTION OF MARINE MAMMALS IN COOK INLET PROJECT AREA

A description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals likely to be affected by such activities.

Descriptions of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals listed in Table 12, above, are presented in the following subsections. Information provided in this section relates to the proposed activities in Cook Inlet. Additional information can be found in Resource Report No. 3 of the ER and its appendices.

4.1. Humpback Whale

Humpback whales were listed as endangered in 1970 under the Endangered Species Conservation Act (predecessor act to the ESA of 1973) primarily due to overexploitation in commercial fisheries (35 Federal Register [FR] 8491). In April of 2015, NOAA proposed to revise the ESA listing for the humpback whale. Although there is considerable distributional overlap in the humpback whale stocks that use Alaskan waters, the whales seasonally found in lower Cook Inlet are probably of the Central North Pacific stock (Barlow, et al. 2011; Allen and Angliss, 2015).

Humpback whale use of Cook Inlet has been observed to be confined to Lower Cook Inlet; the whales have been regularly seen near Kachemak Bay during the summer months (Rugh et al., 2005). There are anecdotal observations of humpback whales as far north as Anchor Point, with recent summer observations extending to Cape Starichkof (Owl Ridge, 2014). Humpback whales will move about their range and it is possible for a small number of humpback whales to be observed near the Marine Terminal construction area but are unlikely to venture north into the proposed Upper Cook Inlet pipeline crossings.

4.2. Beluga Whale

The Cook Inlet beluga whale distinct population segment (DPS) is a small, geographically isolated, and genetically distanced population separated from other beluga populations by the Alaska Peninsula (O’Corry-Crowe et al., 1997). The Cook Inlet beluga DPS was originally estimated at 1,300 whales in 1979 (Calkins, 1989) and has been the focus of management concerns since experiencing a dramatic decline between 1994 and 1998, when the stock declined 47 percent, attributed to overharvesting by subsistence

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 31

hunting (Mahoney and Shelden, 2000). Prior to subsistence hunting restrictions, harvest was estimated to annually remove 10 to 15 percent of the population (Mahoney and Shelden, 2000). Only five belugas have been harvested since 1999, yet the population has continued to decline. NOAA Fisheries listed the population as “depleted” in 2000 because of the decline, and as “endangered” under the ESA in 2008 when the population failed to recover following a moratorium on subsistence harvest.

In April 2011, National Marine Fisheries Service (NMFS) designated critical habitat for Cook Inlet beluga whales (76 FR 20180) in two specific areas of Cook Inlet:

- Area 1. All marine waters of Cook Inlet north of a line from the mouth of Threemile Creek (61°08.5' N., 151°04.4' W.) connecting to Point Possession (61°02.1' N., 150°24.3' W.), including waters of the Susitna River south of 61°20.0' N., the Little Susitna River south of 61°18.0' N., and the Chickaloon River north of 60°53.0' N (Figure 8).
- Area 2. All marine waters of Cook Inlet south of a line from the mouth of Threemile Creek (61°08.5' N., 151°04.4' W.) to Point Possession (61°02.1' N., 150°24.3' W.) and north of 60°15.0' N., including waters within 2 nautical miles seaward of MHHW along the western shoreline of Cook Inlet between 60°15.0' N. and the mouth of the Douglas River (59°04.0' N., 153°46.0' W.); all waters of Kachemak Bay east of 151°40.0' W.; and waters of the Kenai River below the Warren Ames bridge at Kenai, Alaska (Figure 8).

The Cook Inlet beluga whale population is estimated to have declined from 1,300 animals in the 1970s (Calkins, 1989) to about 340 animals in 2014 (Shelden et al., 2015). The current population estimate is 328 animals (Shelden et al., 2017). The precipitous decline documented in the mid-1990s was attributed to unsustainable subsistence practices by Alaska Native hunters (harvest of more than 50 whales per year) (Mahoney and Shelden, 2000). In 2006, a moratorium of the harvest of Cook Inlet beluga whales was agreed upon through a cooperative agreement between the Cook Inlet Marine Mammal Council and NOAA Fisheries.

NOAA Fisheries listed the population as depleted in 2000 because of the decline and as endangered under the ESA in 2008 when the population failed to recover following a moratorium on subsistence harvest (65 FR 34590). NOAA Fisheries finalized the Conservation Plan for the Cook Inlet beluga in 2008 (NMFS 2008), and finalized the Recovery Plan for Cook Inlet beluga whales in 2016 (NMFS, 2016a).

During late spring, summer, and fall, beluga whales concentrate near the Susitna River mouth, Knik Arm, Turnagain Arm, and Chickaloon Bay (Nemeth et al., 2007) where they feed on migrating eulachon and salmon (Moore et al., 2000). Critical Habitat Area 1 reflects this summer distribution (Figure 8). During winter, beluga whales concentrate in deeper waters in the mid-inlet to Kalgin Island, and in the shallow waters along the west shore of Cook Inlet to Kamishak Bay.

Although belugas may be found throughout Cook Inlet at any time of year, they generally spend the ice-free months in Upper Cook Inlet and expand their distribution south and into more offshore waters of Upper Cook Inlet in winter. These seasonal movements appear to be related to changes in the physical environment from sea ice and currents, to shifts in prey resources (NMFS, 2016a). Belugas spend the most of their time year-round in the coastal areas of Knik Arm, Turnagain Arm, Susitna Delta, Chickaloon Bay,

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 32

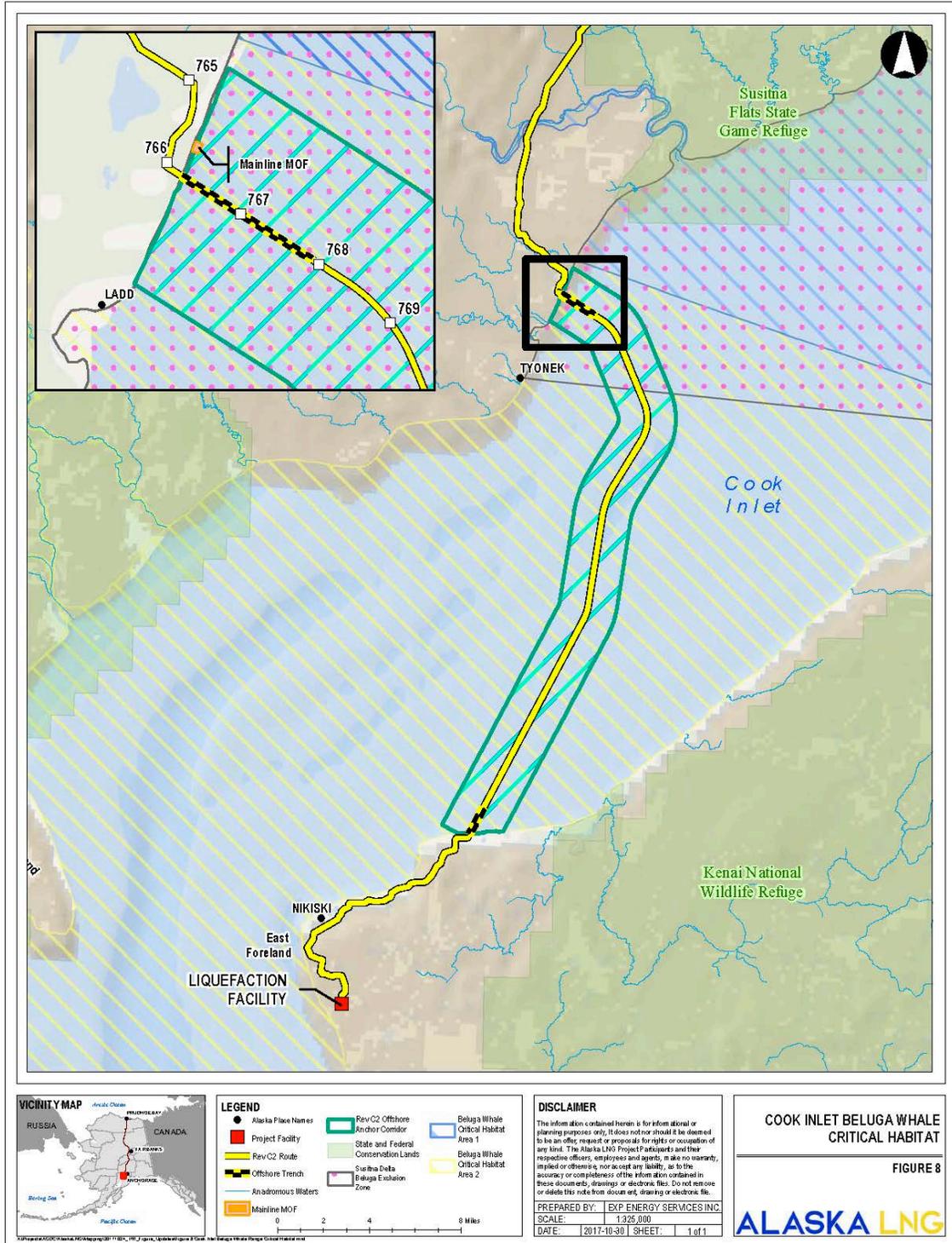
and Trading Bay (Goetz et al., 2012). During the open-water months in Upper Cook Inlet (north of the Forelands), beluga whales are typically concentrated near river mouths (Rugh et al., 2010). The winter distribution of this stock is not well known; however, evidence exists that some whales may inhabit Upper Cook Inlet year-round (Hansen and Hubbard, 1999; Rugh et al. 2004; Hobbs et al., 2005). Satellite tags from 10 whales tagged from 2000 through 2002 transmitted through the fall, and of those, three tags deployed on adult males transmitted through April and late May. None of the tagged beluga moved south of Chinitna Bay on the western side of Cook Inlet. A review of all marine mammal surveys conducted in the Gulf of Alaska from 1936 to 2000 discovered only 31 beluga sightings among 23,000 marine mammal sightings, indicating that very few belugas occur in the Gulf of Alaska outside of Cook Inlet (Laidre et al., 2000 cited in Allen and Angliss, 2014).

Based on these studies, the Applicant anticipates that beluga whales are most likely to occur near the Marine Terminal in moderate densities during the period when sea ice is typically present in Cook Inlet north of the Forelands (December through May; Goetz et al., 2012). Few belugas may occur near the Marine Terminal during the ice-free period (June through November). Belugas would not be expected to focus their foraging (dive) efforts near the proposed Marine Terminal location. If belugas do forage near the Marine Terminal, their foraging dives are more likely to be long and deep during the sea-ice season (December through May; Goetz et al., 2012).

Beluga whales could be found in the vicinities of the Mainline crossing during summer–fall and the Marine Terminal construction area during winter. Previous marine mammal surveys conducted between the Beluga River and the West Forelands (Nemeth et al., 2007; Brueggeman et al., 2007a, b; Lomac-MacNair et al., 2013, 2014; Kendall et al., 2015) suggest that beluga whale numbers near the proposed MOF on the west side of Cook Inlet and the pipeline landing peak in May and again in October, with few whales observed in the months in between. Beluga whales are expected to occur along the entire portion of the Mainline route within upper Cook Inlet year-round, but as discussed previously, beluga distribution is concentrated in shallow coastal waters near Knik Arm, Chickaloon Bay, and Trading Bay during the ice-free season (June through November); and in deeper waters of the Susitna Delta, and offshore between East and West Forelands, and around Fire Island during the sea-ice season (December through May) (Goetz et al., 2012). Belugas may remain near the Mainline during the winter (December through May).

Belugas forage in the Trading Bay area from June to through November (Goetz et al., 2012). Belugas may remain near the Mainline during the winter (December through May) (Goetz et al., 2012). Belugas would be expected to focus their foraging (dive) efforts near the Trading Bay area during June to November, south of where the proposed Mainline would enter Cook Inlet.

Figure 8: Cook Inlet Beluga Whale Range and Critical Habitat



ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 34

4.3. Killer Whale

Killer whales are widely distributed, although they occur in higher densities in colder and more productive waters (Allen and Angliss, 2015). Two different stocks of killer whales inhabit the Cook Inlet region: the Alaska Resident Stock and the Gulf of Alaska, Aleutian Islands, Bering Sea Transient Stock (Allen and Angliss, 2015).

Killer whales are occasionally observed in Lower Cook Inlet, especially near Homer and Port Graham (Shelden et al., 2003; Rugh et al., 2005). A concentration of sightings near Homer and inside Kachemak Bay may represent high use, or high observer-effort given most records are from a whale-watching venture based in Homer. The few whales that have been photographically identified in Lower Cook Inlet belong to resident groups more commonly found in nearby Kenai Fjords and Prince William Sound (Shelden et al., 2003). Prior to the 1980s, killer whale sightings in Upper Cook Inlet were very rare (Rugh et al., 2005). During aerial surveys conducted between 1993 and 2004, killer whales were observed on only three flights, all in the Kachemak and English Bay area (Rugh et al., 2005). However, anecdotal reports of killer whales feeding on belugas in Upper Cook Inlet began increasing in the 1990s, possibly in response to declines in sea lions and harbor seals elsewhere (Shelden et al., 2003). Observations of killer whales in beluga summering grounds have been implicated as a possible contributor to decline of Cook Inlet belugas in the 1990s, although the number of confirmed mortalities from killer whales is small (Shelden et al., 2003). Recent industry monitoring programs only reported a few killer whale sightings (Kendall et al., 2015). The sporadic movements and small numbers of this species suggest that there is a rare possibility of encountering this whale during both Marine Terminal construction and Mainline pipelay. There is, however, a greater possibility of transiting vessels associated with the Project encountering killer whales during transit through lower Cook Inlet.

4.4. Harbor Porpoise

The Gulf of Alaska harbor porpoise stock is distributed from Cape Suckling to Unimak Pass (Allen and Angliss, 2015). They are found primarily in coastal waters less than 328 feet deep (Hobbs and Waite, 2010) where they feed on Pacific herring (*Clupea pallasii*), other schooling fishes, and cephalopods.

Although harbor porpoises have been frequently observed during aerial surveys in Cook Inlet, most sightings are of single animals, and the sightings have been concentrated nearshore between Iliamna and Tuxedni bays on the lower west side of Lower Cook Inlet (Rugh et al., 2005; Shelden et al., 2013). None were recorded from near Nikiski during NOAA Fisheries aerial surveys conducted between 1993 and 2012 (Shelden et al., 2013). Dahlheim et al. (2000) estimated the 1991 Cook Inlet-wide population at 136 animals. However, they are one of the three marine mammals (besides belugas and harbor seals) regularly seen in Upper Cook Inlet (Nemeth et al., 2007), especially during spring eulachon and summer salmon runs. Brueggeman et al. (2007a,b) also reported small numbers of harbor porpoise between Granite Point and the Beluga River. Recent industry monitoring programs in Lower and Middle Cook Inlet reported harbor porpoise sightings in all summer months (Lomac-MacNair et al., 2013, 2014; Kendall et al., 2015). Because harbor porpoise have been observed throughout Cook Inlet during the summer months, they represent a species that could be encountered during all phases and locations of construction.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 35

4.5. Harbor Seal

Harbor seals inhabit coastal and estuarine waters along the West Coast, including southeast Alaska west through the Gulf of Alaska and Aleutian Islands, in the Bering Sea and Pribilof Islands (Allen and Angliss, 2015). At more than 150,000 animals state-wide, harbor seals are one of the more common marine mammal species in Alaskan waters (Allen and Angliss, 2015). Harbor seals haul out on rocks, reefs, beaches, and drifting glacial ice (Allen and Angliss, 2015).

Large numbers of harbor seals concentrate at the river mouths and embayments of Lower Cook Inlet, including the Fox River mouth in Kachemak Bay (Rugh et al., 2005). Montgomery et al. (2007) recorded over 200 haul-out sites in Lower Cook Inlet alone. However, only a few hundred seals seasonally occur in Upper Cook Inlet (Rugh et al., 2005; Shelden et al., 2013), mostly at the mouth of the Susitna River where their numbers vary in concert with the spring eulachon and summer salmon runs (Nemeth et al., 2007; Boveng et al., 2012). In 2012, up to 83 harbor seals were observed hauled out at the mouths of the Theodore and Lewis rivers during April to May monitoring activity associated with a Cook Inlet seismic program (Brueggeman, 2007a). Montgomery et al. (2007) also found seals elsewhere in Cook Inlet to move in response to local steelhead (*Onchorhynchus mykiss*) and salmon runs. Recent industry monitoring programs in Lower and Middle Cook Inlet reported harbor seal sightings in all summer months, both in-water and on haul-outs (Lomac-MacNair et al., 2013, 2014; Kendall et al., 2015). During summer, small numbers of harbor seals are expected to occur near both the Marine Terminal construction area near Nikiski, and along the proposed Mainline pipeline crossing route.

5. REQUESTED TYPE OF INCIDENTAL TAKING AUTHORIZATION

The type of incidental taking authorization that is being requested and the method of incidental taking.

The Applicant requests ITRs from NOAA Fisheries for the incidental take by harassment (Level B as defined in 50 CFR 216.3) of a small number of marine mammals during its planned operations from 2019–2024. The operations outlined in Sections 1 and 2 have the potential to result in takes by harassment of marine mammals by acoustic disturbance during operations. The effects would depend on the species and the distance and received level of the sound (Section 7). Temporary disturbance or localized displacement reactions are most likely to occur. With implementation of the mitigation and monitoring measures described in Sections 11 and 13, no takes by injury or mortality (Level A) are anticipated and takes by disturbance (Level B) are expected to be minimized.

6. NUMBER OF INCIDENTAL TAKES BY ACTIVITIES

By age, sex, and reproductive condition, the number of marine mammals [by species] that may be taken by each type of taking, and the number of times such takings by each type of taking are likely to occur.

6.1. Regulatory Acoustic Criteria

Under the MMPA, NOAA Fisheries has 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.”

For Level A, the NOAA Technical Memorandum NMFS-OPR (NMFS, 2016b) provides guidelines for assessing the onset of permanent threshold shifts (PTSs) from anthropogenic sound. Under these guidelines, marine mammals are separated into five functional hearing groups; source types are separated into impulsive (impact pile driving) and non-impulsive (vibratory pile driving); and analyses of the distance to the peak received sound pressure level (L_{pk}) and 24-hour cumulative sound exposure level (SEL_{24h}) are required.

The current Level B (disturbance) threshold for assessing the onset of temporary threshold shifts (TTSs) for impulsive sound is 160 decibels referenced to 1 microPascal root mean square (dB re 1 μ Pa rms) and 120 dB re 1 μ Pa rms for non-impulsive sound for all marine mammals.

NOAA Fisheries has also established an airborne disturbance threshold of 90 dB re 20 μ Pa (un-weighted) for harbor seals. The nearest documented harbor seal haul-out to the Marine Terminal construction site is near the mouth of the Kenai River approximately 8 miles south of the proposed Marine Terminal where the pile driving would take place (Montgomery et al., 2007). Because none of the pinniped haulouts in Cook Inlet occur within the areas that the proposed construction activities ensound to levels exceeding 90 dB, there is no potential for Level B harassment of hauled out pinnipeds. Airborne sound is not assessed further in this document.

Table 13 provides a summary of the disturbance guidelines. For purposes of this section, all underwater sound pressure levels (SPLs) are reported as dB re 1 μ Pa and all airborne SPLs are reported as dB re 20 μ Pa.

Table 13: Marine Mammal Injury and Disturbance Thresholds for Underwater Sound

Marine Mammals	Disturbance (Level B) Threshold		Injury (Level A) Threshold	
	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive
Low-Frequency Cetaceans	160 dB rms	120 dB rms	219 dB Lpk 183 dB SEL	199 dB SEL
Mid-Frequency Cetaceans	160 dB rms	120 dB rms	230 dB Lpk 185 dB SEL	198 dB SEL
High-Frequency Cetaceans	160 dB rms	120 dB rms	202 dB Lpk 155 dB SEL	173 dB SEL
Phocid Pinnipeds	160 dB rms	120 dB rms	218 dB Lpk 185 dB SEL	201 dB SEL
Otariid Pinnipeds	160 dB rms	120 dB rms	232 dB Lpk 203 dB SEL	219 dB SEL

6.2. Description of Underwater Sound Sources

The two primary underwater sound sources associated with the Project that could potentially affect marine mammals include:

- Impact and vibratory pile driving (sheet and pipe piles) associated with the Marine Terminal and Mainline MOF construction.
- Anchor handling associated with the pipelay of the Mainline across Cook Inlet.

6.2.1. Dredging and Trenching

Other underwater sound sources expected during the construction phase of the Project include sound associated with dredging and trenching. These sound sources are considered non-impulsive sounds, and all exceed the 120 dB rms disturbance threshold at the source, but are not considered to result in Level B harassments by NOAA Fisheries. Measured sound levels for these activities diminish to less than 120 dB rms within approximately 135 meters (219 yards) (Table 14). URS (2007) measured underwater sound levels between 136 and 141 dB re 1 μ Pa rms at 12 to 19 meters (13 to 21 yards) associated with U.S. Army Corps of Engineers (USACE) dredging activities at Anchorage. Dredging is therefore not considered further in this document with regard to calculation of marine mammal exposure estimates.

Table 14: Representative Underwater Sound Levels from Other Proposed Activities

Activity	Sources	SPL Documented	Source Level Ref. to 11 yd.	Distance to Threshold	Source
Dredging	Clamshell dredge of mixed coarse sand/gravel	113 dB @ 179.4 yd	136.5 dB	68 m (74.4 yd)	Dickerson et al. (2001)
	Clamshell dredge in soft sediments	107 dB @ 11 yd	107 dB	3 m (3.3 yd)	Dickerson et al. (2001)
	Winching in/out	117 dB @ 164 yd	140.5 dB	107 m (117 yd)	Dickerson et al. (2001)
	Dumping into barge	109 dB @ 164 yd	132.5 dB	43 m (47 yd)	Dickerson et al. (2001)
	Empty barge at placement site	109 dB @ 345.6 yd	139 dB	135 m (98.4 yd)	Dickerson et al. (2001)
	Clamshell dredge at the POA	141 dB @ 13.1 yd	142.6 dB	178 m (147.6 yd)	URS (2007)
Underwater trenching	With backhoe in shallow water	125 dB @ 109 yd	145 dB	178 m (194.6 yd)	Greene et al. (2007)

6.2.2. Impact Pile Driving

Illingworth & Rodkin (2007) compiled measured near-source (10 meter) SPL data from impact pile driving for pile sizes ranging in diameter from 12 to 96 inches. As described in Section 1, the pile sizes associated for this Project include 18, 24, 48, and 60 inches and sheet piles. For this petition, the source level of the 24-inch pile measured at a depth of 15 meters (49.2 yards) from Illingworth & Rodkin (2007) was used for the Project's 18- and 24-inch piles; the source level of the 60-inch pile from Illingworth & Rodkin (2007) was used for the Project's 48- and 60-inch piles; and the source level of the 24-inch AZ steel sheet pile from Illingworth & Rodkin (2007) was used for the Project's sheet pile. Those source levels are shown in Table 15.

Table 15: Near-Source Sound Pressure Levels from Impact Pile Driving

Representative Pile Type and Approximate Size ¹	Water Depth	Average Sound Pressure Level (dB) ²			Project Pile
		Peak	rms	SEL	
24-inch AZ sheet pile	15 meters 49 feet	205	190	180	Sheet pile
24-inch steel pipe pile	15 meters 49 feet	207	194	178	18 and 24-inch piles
60-inch steel cast-in-steel-shell pile	5 meters 49 feet	210	195	185	48 and 60-inch piles

¹ Compiled by Illingworth & Rodkin (2007)

² Source level distance is approximately 10 meters (33 feet)

6.2.3. Vibratory Pile Driving

Vibratory pile drivers use a system of counter-rotating eccentric weights to transmit vertical vibrations into the pile. These vibrations “liquefy” the contacted sediments, allowing easy gravitational sinking into the sediment bed, facilitated by the heavy-weighted hammer.

Illingworth & Rodkin (2007) compiled measured near-source (10 meters / 33 feet) SPL data from vibratory pile driving for pile sizes ranging in diameter from 12 to 96 inches. As described in Section 1, the pile sizes associated for this Project include 18, 24, 48, and 60 inches and sheet piles. For this petition, the source level of the 72-inch pile from Illingworth & Rodkin (2007) was used for the all of the Project’s vibratory piles per NMFS recommendation (personal communication Shane Guan); and the source level of the 24-inch AZ steel sheet pile from Illingworth & Rodkin (2007) was used for the Project’s sheet pile. Those sources are shown in Table 16.

Table 16: Near-Source Sound Pressure Levels from Vibratory Pile Driving

Representative Pile Type and Approximate Size ¹	Water Depth	Average Sound Pressure Level (dB) ²			Project Pile
		Peak	rms	SEL	
24-inch AZ sheet pile	15 meters 49 feet	175	160	160	Sheet pile
72-inch steel pipe pile	5 meters 16 feet	183	170	170	All size piles

¹ Compiled by Illingworth & Rodkin (2007)

² Source level distance is approximately 10 meters (33 feet)

6.2.4. Vessel Sounds Associated with Construction Activities

Some vessels such as tugs and cargo ships can under some circumstances generate underwater sound exceeding the non-impulsive threshold of 120 dB due largely to the continuous cavitation sound produced from the propeller arrangement of both drive propellers and thrusters. Underwater sound levels associated with offshore pipelay operations include general sounds from the pipelay vessel such as those associated with winching of anchor cables, and thruster sound from the AHTs during anchor pulling. Large

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 39

ships produce broadband SPLs of about 180 dB re 1 μ Pa rms at 1 m (Richardson et al., 1995; Blackwell and Greene, 2003). However, because these sound levels are transient (the vessel is moving), NOAA Fisheries does not consider transiting vessel sound to rise to the level of “take” (S. Guan, NOAA Fisheries, pers. comm.). Thus, there is no requirement to quantify threshold-level sound exposures of marine mammals in an MMPA assessment.

Thrusters have generally smaller blade arrangements operating at higher rotations per minute (rpm) and, therefore, largely produce more cavitation sound than drive propellers. For example, Blackwell and Greene (2003) measured a tug pushing a full barge near the Port of Anchorage and recorded SPLs equating to 163.8 dB re 1 μ Pa rms at 1 meter. The sound emanating from the same tug increased dramatically to 178.9 dB re 1 μ Pa rms at 1 meter (based on a measured 149 dB re 1 μ Pa rms at 100 meters / 328 feet) when the tug was using its thrusters to maneuver the barge during docking.

The Applicant intends to use similar vessels to handle anchors, so the source level of 178.9 dB re 1 μ Pa rms at 1 meter was used to assess Level B exposures.

6.3. Estimating Potential Marine Mammal Exposures

The numbers of each marine mammal species that could potentially be exposed to sound associated with the Project were estimated using the methods described below. We multiplied the following variables: 1) the area of ensonification for the various Level A and B thresholds, 2) the total duration in days for each season for each type of activity; and 3) the density (number of marine mammals/unit area).

6.3.1. Level A Ensonification Area

Using the peak SPL and SEL source levels from Illingworth & Rodkin (2007) for each pile type, the distances to the Level A thresholds were calculated using the NMFS Acoustical Guidance Spreadsheet (NMFS, 2016b) assuming the following:

- Impact Pile Driving
 - Weighting Factor Adjustment (WFA) of 2 kHz.
 - Actual pile driving occurs during 25 percent of a 12-hour day.
 - Number of strikes per hour of 1,560 (based on 26 beats per minute of typical impact hammer).
 - Spreading loss of 15 log R (practical spreading).
- Vibratory Pile Driving
 - WFA of 2.5 kHz.
 - Actual pile driving occurs during 40 percent of a 12-hour day.
 - Spreading loss of 15 log R (practical spreading).
- Anchor Handling
 - WFA of 1.5 kHz.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 40

- Vessel speed of 1.54 meters per second or 3 knots.
- Spreading loss of 17.8 log R (based on Blackwell and Greene 2003).

Underwater sound propagation depends on many factors including sound speed gradients in water, depth, temperature, salinity, and bottom composition. In addition, the 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 thresholds, simple transmission loss (TL) can be calculated using the logarithmic spreading loss with the formula:

$$TL = B * \log_{10}(R), \text{ where TL is transmission loss, B is logarithmic loss, and R is radius.}$$

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. Several projects have measured the TL associated with pile driving in Cook Inlet. At Port MacKenzie in upper Cook Inlet, Blackwell (2005) measured levels associated with impact and vibratory hammer of 36-inch steel pipe and report a TL of 17.5 log R for impact driving and 21.8 to 28 log R for vibratory driving. URS (2007) and SFS (2009) measured levels associated with impact and vibratory pile driving at the Port of Anchorage and used 20 log R to estimate distances to the NOAA Fisheries thresholds, but did not characterize the TL. Illingworth & Rodkin (2013) measured levels from impact hammering of conductor pipe in lower Cook Inlet and report a TL of 20.4 log R. Based on measurements in Cook Inlet with similar types of construction, the 20 log R TL represents the average of the measured TLs; however, AGDC has agreed to use a TL of 15 log R for assessment of potential exposures from pile driving. For the anchor handling, the measurements of tugs docking in Cook Inlet conducted by Blackwell and Greene (2003) represent a similar source level, similar environment, and similar operations; so the measured source level of 149 dB at 100 meters and TL of 17.8 log R best approximate conditions expected for the project.

The area is then calculated using the formula for area of a circle ($A = \pi r^2 / 10^6$) where r is the distance to the threshold. For pile driving, the area is then divided by two, as the sound would only propagate in water (half of a circle); a full circle was used for anchor handling.

The estimated distances to the thresholds for pile driving and anchor handling are summarized in Table 17. For the Level A peak thresholds for impact pile driving, the estimated distances for all marine mammals are less than 5 meters resulting areas of ensonification are 0 square kilometers. For the Level A SEL thresholds for impact pile driving, the estimated distances are approximately 4,500 meters and the resulting area of ensonification is approximately 32 square kilometers. It is important to note that the distance for SEL includes the amount of accumulated time over the 24-hour period, so the size will change if the time varies. For the Level A SEL thresholds for vibratory pile driving, the estimated distances for all marine mammals is less than 120 meters and the resulting area of ensonification is 0.02 square kilometers. The Applicant may perform an SSV at the beginning of the pile driving to characterize the sound levels associated with different pile and hammer types, as well as to establish the marine mammal monitoring and mitigation zones.

Table 17: Calculated Distances in Meters to NOAA Fisheries Level A Thresholds

Activity ¹	SEL _{cum}	Low Frequency Cetaceans Impact WFA: -0.01 Vibratory WFA: -0.05 Anchor WFA: -0.00			Mid Frequency Cetaceans Impact WFA: -19.74 Vibratory WFA: -16.83 Anchor WFA: -23.59			High Frequency Cetaceans Impact WFA: -26.87 Vibratory WFA: -23.50 Anchor WFA: -31.27			Phocids Impact WFA: -2.08 Vibratory WFA: -1.29 Anchor WFA: -3.43			Otariids Impact WFA: -1.15 Vibratory WFA: -0.60 Anchor WFA: -2.27		
		Impulsive		Non-Impulsive	Impulsive		Non-Impulsive	Impulsive		Non-Impulsive	Impulsive		Non-Impulsive	Impulsive		Non-Impulsive
		219 dB pk	183 dB SEL	199 dB SEL	230 dB pk	185 dB SEL	198 dB SEL	202 dB pk	155 dB SEL	173 dB SEL	218 dB pk	185 dB SEL	201 dB SEL	232 dB pk	203 dB SEL	219 dB SEL
18- and 24-inch pipe, impact	215	2	1,297	NA	0	46	NA	0	1,545	NA	1	694	NA	0	51	NA
48- and 60-inch pipe, impact	222	3	3,798	NA	0	135	NA	1	4,524	NA	2	2,033	NA	0	148	NA
all sizes pipe, vibratory	NA	NA	NA	77	NA	NA	7	NA	NA	114	NA	NA	47	NA	NA	3
Sheet pile, impact	217	1	1,763	NA	0	63	NA	0	2,100	NA	1	943	NA	0	69	NA
Sheet pile, vibratory	NA	NA	NA	17	NA	NA	1	NA	NA	25	NA	NA	10	NA	NA	1
Anchor handling	NA	NA	NA	0.02	NA	NA	0.00	NA	NA	0.01	NA	NA	0.01	NA	NA	0.00

¹Source levels from Illingworth & Rodkin (2007) as summarized in Tables 15 and 16. All source levels presented in dB re 1 μPa at 1 m.

Distances using Weighting Factor Adjustments (WFA) calculated per NMFS Acoustical Technical Guidance (NMFS 2016b) assuming 2 kHz for impact, 2.5 kHz for vibratory, and 1.5 kHz for anchor handling.

SEL_{cum} assuming 25 percent per 12-hour work day actual pile driving and 1,560 strikes per hour.

Distance to impulsive SEL threshold for impact pile driving assumes SEL_{cum} and 15 log R spherical spreading loss.

Distance to non-impulsive SEL threshold for vibratory pile driving assumes 15 log R spherical spreading and 40 percent per 12-hour work day actual pile driving.

Distance to non-impulsive SEL threshold for anchor handling assumes source level of 178.9 dB re 1 Pa rms from Blackwell and Greene (2003), vessel speed of 1.54 m/s, and 17.8 log R spreading loss.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 42

6.3.2. Level B Ensonification Area

The distances to the Level B thresholds were calculated assuming the following:

- Pile Driving
 - Using the rms source levels from Illingworth & Rodkin (2007) for each pile type as summarized in Table 15 and Table 16.
 - Spreading loss of 15 log R (practical spreading).
- Anchor Handling
 - Using rms source level from Blackwell and Greene (2003) of 178.9 dB re 1 μ Pa.
 - Spreading loss of 17.8 log R (based on Blackwell and Greene, 2003)

The ensonified area is calculated using the formula for area of a circle ($A = \pi r^2 / 10^6$) where r is the distance to the threshold. For pile driving, the area is then divided by two, as the sound would only propagate in water (half of a circle); a full circle was used for anchor handling.

The estimated distances to the Level B thresholds for pile driving and anchor handling are summarized in Table 18. The estimated distances to the appropriate thresholds for all marine mammals are less than approximately 2,100 meters for impact pile driving of all sizes of piles, between approximately 4,700 meters and 21,500 meters for vibratory pile driving, and approximately 2,000 meters for anchor handling. The resulting areas of ensonification range from 1.5 to 7.3 square kilometers for impact pile driving; between 33 and 729 square kilometers for vibratory pile driving; and 13 square kilometers for anchor handling.

Table 18: Calculated Distances to NOAA Fisheries Level B Thresholds

Activity	Impulsive 160 dB rms meters (yards)	Non-Impulsive 120 dB rms meters (yards)
18 and 24-inch pipe, impact ¹	1,848 (2,020)	NA
48 and 60-inch pipe, impact ¹	2,154 (2,355)	--
all sizes pipe, vibratory ¹	--	21,544 (26,805)
Sheet pile, impact ¹	1,000 (1,093)	--
Sheet pile, vibratory ¹	--	4,642 (5,076)
Anchor handling ²	--	2,037 (2,228)

¹ Pile driving source levels from Illingworth & Rodkin (2007) as summarized in Tables 15 and 16. All source levels presented in dB re 1 μ Pa rms at 1 m. Distances calculated for pile driving assuming 15 log R practical spreading.

² Anchor handling source level from Blackwell and Greene (2003). Distances calculated for anchor handling assuming 17.8 log R spreading from Blackwell and Greene (2003).

6.3.3. Duration of Sound per Activity

Estimated durations in total number of 24-hour days were estimated per season, per facility, and by pile type and size are provided in Table 19. The total number of structures (bents or quadropods) and needed days for driving the piles are based on an assumed period of April through October, a 12-hour work day, 25 percent of actual driving for impact pile driving, and 40 percent of actual driving for vibratory pile driving.

Table 19: Calculation of Duration of Pile Driving in Total Days for Each Facility and Season

Product Loading Facility											
Season	Element	Number of Piles/Length of Sheet Pile					Hammer	Months	Total Number of Structures	Number of Pile Driving Days per Structure	Total 24-hour Periods
		18-inch	24-inch	48-inch	60-inch	Length of Sheet					
2	E-W Access Trestle	-	-	-	33	-	Impact	April–June	11	2	5.50
2	E-W Access Trestle	-	-	-	40	-	Impact	June–August	10	2	5.00
2	Berth 1	-	-	20	-	-	Impact	April–May	4	2	2.00
2	Berth 2	-	-	20	-	-	Impact	April–May	4	2	2.00
2	N-S Access Trestle	-	-	40	-	-	Impact	May–June	8	2	4.00
3	E-W Access Trestle	-	-	-	28	-	Impact	April–May	7	2	3.50
3	Operations Platform	-	-	-	12	-	Impact	May–June	3	2	1.50
3	Breasting Dolphin Berth 1 & 2	-	-	8		-	Impact	April–May	2	2	1.00
3	Breasting Dolphin Berth 1 & 2	-	-		32	-	Impact	April–May	6	2	3.00
3	Mooring Dolphin	-	-	2		-	Impact	May	1	2	0.50
3	Mooring Dolphin				8		Impact	May	1	2	0.50
3	N-S Access Trestle	-	-	30	-	-	Impact	April–May	6	2	3.00
4	Mooring Dolphin	-	-	10		-	Impact	April–June	3	2	1.50
4	Mooring Dolphin				40	-	Impact	April–June	7	2	3.50
4	Catwalk	-	-	-	8	-	Impact	April–May	8	2	4.00

(Table 19 Continued)

Temporary Material Offloading Facility											
Season	Element	Number of Piles/Length of Sheet Pile					Hammer	Months	Total Number of Structures	Number of Pile Driving Days per Structure	Total 24-hour Periods
		18-inch	24-inch	48-inch	60-inch	Length of Sheet					
1	MOF combi wall	-	-	-	35		Vibratory	July	1	10.75	4.30
1	MOF combi wall					1075	Vibratory	July	1	10.75	4.30
1	MOF cell	36	-	-	-		Vibratory	July–October	1	27.54	11.02
1	MOF cell					2454	Vibratory	July–October	1	27.54	11.02
2	MOF cell	30	-	-	-		Vibratory	April–June	1	26.97	10.79
2	MOF cell					2447	Vibratory	April–June	1	26.97	10.79
2	MOF Ro-Ro Dolphin Quads	-	-	28	-	-	Impact	April–June	3.5	2	1.75
2	MOF Ro-Ro Dolphin Quads	-	7	-	-	-	Impact	April–June	3.5	2	1.75
Mainline Material Offloading Facility											
Season	Element	Number of Piles/Length of Sheet Pile					Hammer	Months	Total Number of Structures	Number of Pile Driving Days per Structure	Total 24-hour Periods
		18-inch	24-inch	48-inch	60-inch	Length of Sheet					
1	Mainline MOF sheet pile	-	-	-	-	670	Vibratory	April–May	1	6.7	3.00
1	Mainline MOF sheet pile	-	-	-	-	670	Impact	April–May	1	6.7	2.00

ALASKA LNG	Petition for ITRs for Alaska LNG	AKLNG-6010-REG-GRD-DOC-00001
	Construction Activities in Cook Inlet,	Revision: 3
	Alaska	February 20, 2018
	Public	Page 46

The total duration per season of anchor handling was calculated differently for the two seasons. In Season 3 the duration was calculated by assuming actual anchor handling would occur 25 percent of each day that anchor handling is ongoing. In Season 4 anchor handling duration was estimated by calculating the likely number of times individual anchors would be reset (based on resetting all 12 anchors once per day and a lay rate of 2,500 feet per day) and assuming it takes 15 minutes to pull the anchor and 15 minutes to reset (Table 20).

Table 20: Calculation of Duration of Anchor Handling in Total Days for Each Season

Season	Activity	Anchors Reset	Reset Time (hours) ¹	Days	Percent of Day	Total 24-hour Periods
3	9 days mooring, 14 days pipe trenching	--	--	23	25%	5.75
4	Pipeline days at rate of 2,500 feet per day	636	0.5	53	25%	13.25

¹ Includes 15 minutes to pull an anchor and 15 minutes to reset (lower and then tension up)

These are estimates, the actual production rates and durations would be dependent on weather, conditions of substrate, equipment, and other delays.

6.3.4. Marine Mammal Densities

Density estimates were calculated for all marine mammals (except beluga whales) by using aerial survey data collected by NOAA Fisheries in Cook Inlet between 2002 and 2012 (summarized in Sheldon et al. 2017) and compiled by Apache Alaska Corporation for their issued ITRs (81 FR 47239). To estimate the average raw densities of marine mammals, the total number of animals for each species observed over the 11-year survey period was divided by the total area of 65,889 square kilometers (25,540 square miles) surveyed over the 11 years (Table 21).

Table 21: Raw and Corrected Marine Mammal Density Estimates for Cook Inlet

Species	Mean Density animals / square kilometer (animals/square mile)
Beluga Whale (Marine Terminal) ^a	0.000158 (0.00041)
Beluga Whale (Mainline Crossing) ^a	0.0107 (0.0277)
Beluga Whale (Beluga MOF) ^a	0.0368 (0.0953)
Killer Whale ^{b, c}	0.000656 (0.0017)
Humpback Whale ^b	0.000037 (0.0001)
Harbor Porpoise ^b	0.00378 (0.0098)
Harbor Seal method 1 ^b	0.2446 (0.6335)
Harbor Seal method 2 ^d	0.1695 (0.4390)

^a Beluga densities were based on average density near facility.

^b Densities calculated by dividing number of animals NOAA Fisheries observed over 11 years of surveys divided by total area surveyed.

^c Killer whale density is for all killer whales regardless of stock.

^d Density calculated as highest number of hauled out seals recorded during the NOAA Fisheries aerial survey divided by area of Upper Cook Inlet; the is method was selected for use in exposure calculations.

6.3.4.1. Harbor Porpoise and Killer Whale

To estimate the average raw densities of harbor porpoise and killer whales, the total number of animals for each species (249 harbor porpoises and 42 killer whales) observed over the 11-year survey period was divided by the total area of 66,148 square kilometers (25,540 square miles) surveyed over the 11 years. These raw densities were not corrected for animals missed during the aerial surveys as no accurate correction factors are currently available for these species; however, observer error may be limited as the NOAA Fisheries surveyors often circled marine mammal groups to get an accurate count of group size.

6.3.4.2. Harbor Seal

The average raw density for harbor seals was also originally calculated in the same manner as harbor porpoise and killer whales (16,117 animals/65,890 square kilometers; 25,440 square miles) in method 1, but resulted in an unrealistically inflated density of 0.2446 seals per square kilometer (0.6335 seals per square mile). This inflated density is due to the bias created by the large number of hauled-out harbor seals at river mouths in the NOAA Fisheries aerial survey database relative to offshore densities.

An alternative harbor seal density estimate was developed (method 2) by taking the highest number of hauled-out seals recorded during the NOAA Fisheries aerial survey (650 seals) and dividing it by the area of Upper Cook Inlet (3,833 square kilometers/1,480 square miles) resulting in a density of 0.1695 seals per square kilometers (0.4390 seals per square mile). This represents the density for the month of June, when the aerial surveys were conducted, the period during which the harbor seal presence (and eulachon run) in Upper Cook Inlet is at its peak. NOAA Fisheries has recognized that harbor seal density estimates derived from both methods above are inflated, especially given that only about 2.2 seals were observed

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 48

per 24-hour period by Lomac-MacNair et al. (2013, 2014) during seismic surveys in previous years in Upper Cook Inlet. NOAA Fisheries may develop alternative harbor seal density estimates (S. Young, NMFS, pers. comm.). The density determined using method 2 (Table 21) was used to calculate the number of exposures for the Project.

6.3.4.3. Beluga Whale

Goetz et al. (2012) modeled aerial survey data collected by NOAA Fisheries between 1993 and 2008 and developed specific beluga whale summer densities for each 1-square-kilometer (0.4-square-mile) cell of Cook Inlet. Given the clumped and distinct distribution of beluga whales in Cook Inlet during the summer months, these results provide a more precise estimate of beluga whale density at a given location than multiplying all aerial observations by the total survey effort. To develop a density estimate associated with planned survey areas, the ensonified area associated with each activity was overlain on a map of the 1-square-kilometer (0.4-square-mile) density cells. The cells falling within each ensonified area were quantified, and an average cell density was calculated.

6.4. Calculation of Potential Unmitigated Acoustic Exposures

We multiplied the following three variables: 1) the area (in square kilometers) of ensonification for Level A and B for pile driving for each size and hammer type (Table 15 and Table 16), 2) the duration (in days) of the sound activity per facility per season (Table 19 and Table 20), and 3) the density (number of marine mammals/ square kilometer; Table 21) to estimate the total number of marine mammals potentially exposed to sound exceeding NOAA Fisheries thresholds (Table 22). These estimates do not include any reductions from mitigation measures, such as shutdowns or construction windows, or reductions from the variability in seasonal habitat use or distribution of the marine mammals in Cook Inlet. The Applicant may perform an SSV at the beginning of the pile driving to characterize the sound levels associated with different pile and hammer types, as well as to establish the marine mammal monitoring and mitigation zones.

The total estimated number of Level A exposures without mitigation was calculated to be fewer than three animals for each species within one season and approximately five animals for each species across all four seasons. The total estimated number of Level B exposures without mitigation was calculated to be less than 5 humpback whales per season and approximately 8 for all four seasons; less than 7 killer whales per season and approximately 12 for all four seasons; less than 6 per season and approximately 10 for all four seasons; less than 43 harbor porpoises per season and approximately 78 for all four seasons; and less than 194 harbor seals per season and approximately 350 for all four seasons.

Table 22: Summary of Unmitigated Number of Marine Mammals Exposed to Level A and Level B Thresholds Per Season and Per Facility

Season	Facility	Activities	Humpback whale		Killer whale		Beluga whale		Harbor porpoise		Harbor seal	
			Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B
1	PLF	Impact pipe pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Temporary MOF	Vibratory & impact, sheet & pipe pile driving	0.000	4.367	0.000	6.550	0.000	1.790	0.000	42.793	0.000	191.693
	Mainline MOF	Vibratory & impact sheet pile driving	0.004	0.040	0.000	0.061	0.000	3.850	0.052	0.396	0.047	1.774
Total Season 1			0.004	4.407	0.000	6.610	0.000	5.641	0.052	43.188	0.047	193.467
2	PLF	Impact pipe pile driving	0.162	0.052	0.000	0.078	0.000	0.028	2.250	0.510	2.034	2.286
	Temporary MOF	Vibratory & impact, sheet & pipe pile driving	0.017	3.329	0.000	4.994	0.000	1.365	0.239	32.597	0.215	146.163
	Mainline MOF	Vibratory & impact sheet pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Season 2			0.179	3.382	0.000	5.072	0.000	1.393	2.489	33.107	2.249	148.449
3	PLF	Impact pipe pile driving	0.000	0.037	0.000	0.055	0.000	0.015	1.581	0.359	1.430	1.606
	Temporary MOF	Vibratory & impact, sheet & pipe pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mainline MOF	Vibratory & impact sheet pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mainline Pipelay	Anchor handling	0.000	0.029	0.000	0.043	0.000	0.801	0.000	0.284	0.000	1.270
Total Season 3			0.000	0.066	0.000	0.098	0.000	0.816	1.581	0.642	1.430	2.876
4	PLF	Impact pipe pile driving	0.079	0.025	0.000	0.038	0.000	0.010	1.095	0.248	0.990	1.112
	Temporary MOF	Vibratory & impact, sheet & pipe pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mainline MOF	Vibratory & impact sheet pile driving	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mainline Pipelay	Anchor handling	0.000	0.067	0.000	0.100	0.000	1.846	0.000	0.653	0.000	2.925
Total Season 4			0.079	0.092	0.000	0.138	0.000	1.856	1.095	0.901	0.990	4.037
Grand Total for All 4 Seasons			0.261	7.946	0.001	11.919	0.001	9.706	5.217	77.839	4.716	348.830

6.4.1. Summary of Requested Takes

The Applicant seeks authorization for the potential taking through disturbance (Level B) of small numbers of humpback whale, beluga whale, killer whale, harbor porpoise, and harbor seal in Cook Inlet. Any takes would most likely result from construction noise, specifically in-water pile driving. These takes may have no more than a minor effect on individual animals or no effect on the populations of these five species. The Applicant does not anticipate any Level A takes with the mitigation measures discussed in Section 11 applied.

The total number of requested annual Level B takes (Table 23) compared to the population estimates in Section 3 is less than 10 percent of the Cook Inlet beluga whale population, which NOAA Fisheries has considered to be the “small numbers” in previously issued IHAs. The total number of requested annual Level B takes for other species is approximately 1.2 percent of the transient stock of killer whales and less than 1 percent of the remaining marine mammals in the Project area. As shown in Table 23, additional Level B takes for beluga whales are requested over the estimated number of exposures. This is necessary to accommodate average group sizes that could be encountered. Therefore, the request would accommodate a small group of animals entering the Project area. These estimates present the worst-case of encountering whales in the Project Area during pile driving.

Table 23: Requested Annual Take Authorizations

Species	Total Estimated Exposure without Mitigation	Annual Take Authorization Requested	Population Estimate	Percent of Population
Humpback whale	4.4	5	10,103	<1%
Killer whale (resident)	6.6	7	2,437	<1%
Killer whale (transient)	6.6		587	1.2%
Beluga whale	5.6	32	328	9.8%
Harbor porpoise	43.2	45	31,046	<1%
Harbor seal	193.5	195	22,900	<1%

7. DESCRIPTION OF IMPACT ON MARINE MAMMALS

The anticipated impact of the activity upon the species or stock.

7.1. General Effects of Sound on Marine Mammals

Marine mammals use hearing and sound transmission to perform vital life functions. Introducing sound into 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 vessel and construction activities are detectable by marine mammals depends on source levels, frequency, ambient sound levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al., 1995).

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 51

The effects of sounds from industrial activities on marine mammals might 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. 1995). In assessing potential effects of sound, Richardson et al. (1995) has suggested four criteria for defining zones of influence. These zones are described below from greatest to least influence.

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 TTS (temporary loss in hearing) or PTS (loss in hearing at specific frequencies or deafness). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage.

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

Zone of responsiveness – the area within which the animal reacts behaviorally or physiologically. The behavioral responses of marine mammals to sound is dependent upon several factors, including: 1) acoustic characteristics of the sound 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 like a predator) (Richardson et al., 1995; Southall et al., 2007). However, temporary behavioral effects are often simply evidence that an animal has heard a sound and may not indicate lasting consequence for exposed individuals (Southall et al., 2007).

Zone of audibility – the area within which the marine mammal might hear the sound. Marine mammals as a group have functional hearing ranges of 10 Hz to 180 kHz, with best thresholds near 40 dB (Ketten, 1994; Kastak et al., 2005; Southall et al., 2007). These data show reasonably consistent patterns of hearing sensitivity within each of three groups: small odontocetes (such as the harbor porpoise), medium-sized odontocetes (such as the beluga and killer whales), and pinnipeds (such as harbor seals). There are no applicable criteria for the zone of audibility due to difficulties in human ability to determine the audibility of a sound for a species.

The following text describes the potential impacts on marine mammals due to the sources associated with this program. Due to relatively low sound levels and short period of time over the entire season the louder activities would occur, and the mitigation measures, it is unlikely there would be any temporary or especially permanent hearing impairment, or non-auditory physical effects on marine mammals.

7.2. Potential Effects of Sounds on Marine Mammals

7.2.1. Tolerance

Studies have shown that underwater sounds from anthropogenic activities are often detectable underwater at distances of many miles away from the source. Studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response to various types of industry activities (Moulton et al., 2005; Harris et al., 2001; LGL et al., 2014). This is often true

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 52

even in cases when the sounds are likely audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. All marine mammals have exhibited some behavioral reaction to underwater industry sounds, but they have also exhibited no overt reactions to underwater sounds (Stone and Tasker, 2006; Hartin et al., 2013). In general, pinnipeds and small odontocetes appear to be more tolerant of exposure to some types of underwater sound than are baleen whales. The Applicant anticipates that some marine mammals would be exposed to the low levels of underwater sounds from Alaska LNG construction activities but the exposures would not result in long-term disturbance.

7.2.2. Temporary Threshold Shift and Permanent Threshold Shift

Sound has the potential to induce TTS or PTS hearing loss (Weilgart, 2007). The level of loss is dependent on sound frequency, intensity, and duration. Like masking, hearing loss reduces the ability of marine mammals to forage efficiently, maintain social cohesion, and avoid predators (Weilgart, 2007). For example, Todd et al. (1996) found an unusual increase in fatal fishing gear entanglement of humpback whales to coincide with blasting activities, suggesting hearing damage from the blasting may have compromised the ability for the whales to use sound to passively detect the nets. Experiments with captive bottlenose dolphins and beluga whales found that short duration impulsive sounds can cause TTS (Finneran et al., 2002).

PTS occurs when continuous sound exposure causes hairs within the inner ear system to die. This can occur due to moderate durations of very loud sound levels, or long-term continuous exposure of moderate sound levels. However, PTS is not an issue with impulsive sound, and continuous sound from the cavitation of boat propellers and thrusters are short-term for a given location, since the vessels are either constantly moving, or operating intermittently.

7.2.3. Hearing Impairment and Other Physical Effects

NOAA Fisheries has developed new sound exposure criteria for marine mammals that account for the currently available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS, 2016b). Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the construction activities to avoid exposing them to underwater sound levels that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the proposed activities. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals near industrial sound sources and beaked whales do not occur in the proposed Project area. It is unlikely

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 53

that any effects of these types would occur during the proposed Project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures.

Available data on the potential for underwater sounds from industrial activities to cause auditory impairment or other physical effects in marine mammals suggest that such effects, if they occur at all, would be temporary and limited to short distances. Marine mammals that show behavioral avoidance of the proposed activities, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Animals exposed to intense sound may experience reduced hearing sensitivity for some period following exposure. This increased hearing threshold is known as sound induced threshold shift (TS). The amount of TS incurred in the animal is influenced by several sound exposure characteristics, such as amplitude, duration, frequency content, temporal pattern, and energy distribution (Kryter, 1985; Richardson et al., 1995; Southall et al., 2007).

It is also influenced by characteristics of the animal, such as behavior, age, history of sound exposure, and health. The magnitude of TS generally decreases over time after sound exposure and if it eventually returns to zero, known as TTS. If TS does not return to zero after some time (generally on the order of weeks), it is known as PTS. Temporary threshold shift is not considered to be auditory injury and does not constitute “Level A Harassment” as defined by the MMPA. Sound levels associated with TTS onset are generally considered to be below the levels that would cause PTS, which is auditory injury. For more information on TTS and PTS, please refer to NMFS Acoustic Criteria for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS, 2016b).

7.2.4. Masking

Masking occurs when louder sounds interfere with marine mammal vocalizations or ability to hear natural sounds in their environment (Richardson et al., 1995), which limit their ability to communicate or avoid predation or other natural hazards. Masking is of special concern for baleen whales that vocalize at low frequencies over long distances, as their communication frequencies overlap with anthropogenic sounds such as shipping traffic. Some baleen whales have adjusted their communication frequencies, intensity, and call rate to limit masking effects. For example, McDonald et al. (1995) found that California blue whales (*Balaenoptera musculus*) have shifted their call frequencies downward by 31 percent since the 1960s, possibly to communicate below shipping sound frequencies. Melcon et al. (2012) found blue whales to increase their call rates in the presence of typically low frequency shipping sound, but to significantly decrease call rates when exposed to mid-frequency sonar. Also, Di Iorio and Clark (2010) found blue whales to communicate more often in the presence of seismic surveys, which they attributed to compensating for an increase in ambient sound levels. Fin whales have reduced their calling rate in response to boat noise (Watkins, 1986).

Odontocetes hear and communicate at frequencies well above the frequencies of pile driving, dredging, and ship propellers/thrusters (Wartzok and Ketten, 1999). Beluga whales have a well-developed and well-documented sense of hearing. White et al. (1978) measured the hearing of two belugas whales and described hearing sensitivity between 1 and 130 kHz, with best hearing between 30 to 50 kHz. Awbrey et

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 54

al. (1988) examined their hearing in octave steps between 125 Hz and 8 kHz, with average hearing thresholds of 121 dB re 1 μ Pa at 125 Hz and 65 dB re 1 μ Pa at 8 kHz. Johnson et al. (1989) further examined beluga hearing at low frequencies, establishing that the beluga whale hearing threshold at 40 Hz was 140 dB re 1 μ Pa. Ridgway et al. (2001) measured hearing thresholds at various depths down to 330 yards at frequencies between 500 Hz and 100 kHz. Beluga whales showed unchanged hearing sensitivity at this depth. Finneran et al. (2005) measured the hearing of two belugas, describing their auditory thresholds between 2 and 130 kHz. In summary, these studies indicate that beluga whales hear from approximately 40 Hz to 130 kHz, with maximum sensitivity from approximately 30 to 50 kHz. It is important to note that these audiograms represent the best hearing of belugas, measured in very quiet conditions. These quiet conditions are rarely present in the wild, where high levels of ambient sound may exist.

It is expected that while odontocetes such as beluga whales and harbor porpoise would be able to detect sound from the planned pile driving and vessel operations, it is unclear whether the operations would mask the ability of these high-frequency animals to communicate.

7.3. Behavioral Response of Marine Mammals

7.3.1. Baleen Whales

Southall et al. (2007) reviewed several 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 90–120 dB re 1 μ Pa rms. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB re 1 μ Pa rms. Some of the relevant reviews of Southall et al. (2007) are summarized as follows.

Humpback Whales

Humpbacks and other large baleen whales have shown strong overt reactions to impulsive sounds, such as seismic operations, at received levels between 160 and 173 dB re 1 μ Pa rms (Richardson et al., 1986; Ljungblad et al., 1988; Miller et al., 2005; McCauley et al., 1998). However, baleen whales seem to be less tolerant of continuous sound (Richardson and Malme, 1993), often detouring around drilling activity when received levels are as low as 119 dB re 1 μ Pa (rms) (Malme et al., 1983; Richardson et al., 1985). Based on the previously cited studies, NOAA Fisheries developed the 120 dB re 1 μ Pa rms harassment criteria for continuous sound sources.

Based upon the information regarding baleen whale disturbance reactions, the Applicant anticipates that some baleen whales may exhibit minor, short-term disturbance responses to underwater sounds from construction activities. Any potential impacts on baleen whale behavior would be localized within the activity area and would not result in population-level effects.

7.3.2. Toothed Whales

Most toothed whales have the greatest hearing sensitivity at frequencies much higher than that of baleen whales and may be less responsive to low-frequency sound commonly associated with industry activities. Richardson et al. (1995) reported that beluga whales did not show any apparent reaction to playback of

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 55

underwater drilling sounds at distances greater than 200–400 meters (656–1,312 feet). Reactions included slowing down, milling, or reversal of course after which the whales continued past the projector, sometimes within 50–100 meters (164–328 feet).

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall et al. (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to nonplused sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound behavioral responses to exposures from 90 to 120 dB re 1 μ Pa rms, while others failed to exhibit such responses for exposure to received levels from 120 to 150 dB re 1 μ Pa rms. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating sound exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB re 1 μ Pa rms before inducing behavioral responses. Below we summarize some of the relevant material reviewed by Southall et al. (2007).

Two papers deal with important issues related to changes in marine mammal vocal behavior as a function of variable background sound levels. Foote et al. (2004) found increases in the duration of killer whale calls over the period 1977 to 2003, during which time vessel traffic in Puget Sound, and particularly whale-watching boats around the animals, increased dramatically. Scheifele et al. (2005) demonstrated that belugas in the St. Lawrence River increased the levels of their vocalizations as a function of the background sound level (the “Lombard Effect”).

Beluga Whales

Cook Inlet beluga whales are familiar with, and likely habituated to, the presence of large vessels. For example, beluga whales near the Port of Anchorage did not appear to be bothered by the sounds from a passing cargo freight ship (Blackwell and Greene, 2003). Beluga whales have displayed avoidance reactions when approached by watercraft, particularly small, fast moving craft that can maneuver quickly and unpredictably. Larger vessels that do not alter course or motor speed around beluga whales seem to cause little, if any, reaction (NMFS, 2008). Disturbance from vessel traffic, whether because of the physical presence of the vessels or the sound created by them, could cause short-term behavioral disturbance to nearby beluga whales, or localized short-term displacement of belugas from their preferred habitats (Richardson et al., 1995). A study conducted by Markowitz and McGuire (2007) found that while beluga whale numbers were generally low near the Port of Anchorage Marine Terminal Redevelopment Project, 64 percent of the groups observed entered the proposed Project footprint (which extended offshore about 150 meters [164 yards]).

Harbor Porpoise

Harbor porpoises are thought to be naturally shy and tend to move away from boats and ships. Reaction to boats can be strong when within 400 meters (437 yards) (Polacheck and Thorpe, 1990) out to 1.5 kilometers (0.9 miles) (Barlow, 1988). There is little information on harbor porpoise reaction to impulsive sound such as pile driving. However, Lucke et al. (2009) recently exposed harbor porpoise to impulsive

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 56

sound signals and found that harbor porpoises showed behavioral aversion to impulsive sounds as low as 174 dB re 1 μ Pa (peak-peak), indicating a greater sensitivity to impulsive sound than beluga whales. Acoustical harassment devices with full spectrum impulsive source levels of 180 dB re 1 μ Pa effectively deterred harbor porpoise from salmon pens (Johnston, 2002).

Dall's Porpoise

Dall's porpoises are known to have an affinity for bow-riding both large and small vessels (Richardson et al., 1995). There is little information on how Dall's porpoise react to pile driving (largely because these animals are rarely found near shore). However, given the lack of sensitivity of other odontocetes to low frequency vessel noise (Richardson et al., 1995) and their propensity to bow-ride, it is not anticipated they would avoid the pipelay vessels if encountered.

Killer Whale

There is very little information on killer whale reactions to boats other than studies on tour boat impacts to inland stocks of Washington and British Columbia. As odontocetes, killer whales are probably less sensitive to low frequency vessel sounds. However, killer whales are sensitive to impulsive sounds (such as pile driving) as evidenced by the effective use of acoustical harassment devices to protect salmon pen fisheries (Morton and Symonds, 2002).

Based upon the above information regarding toothed whale disturbance reactions, the Applicant anticipates that some toothed whales may exhibit minor, short-term disturbance responses to underwater sounds from construction and sonar activities. Any potential impacts on toothed whale behavior would be localized within the activity area and would not result in population-level effects.

7.3.3. *Pinnipeds*

Harbor Seal

Literature suggests that pinnipeds may be tolerant of underwater industrial sounds, and they are less sensitive to lower frequency sounds. Pinnipeds generally seem to be less responsive to exposure to industrial sound than most cetaceans. Pinniped responses to underwater sound from some types of industrial activities such as seismic exploration appear to be temporary and localized (Harris et al., 2001; Reiser et al., 2009).

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between ~90 and 140 dB re 1 μ Pa rms generally do not appear to induce strong behavioral responses in pinnipeds exposed to nonplused sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to nonplused exposures in water, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 57

Richardson et al. (1995) were not aware of any detailed data on reactions of seals to impulsive sounds (seismic in this case), and expected them to tolerate or habituate to underwater sound, especially if food sources were present. Most information on the reaction of seals and sea lions to boats relates to disturbance of animals hauled out on land. There is little information on the reaction of these pinnipeds to ships while in the water, other than some anecdotal reports that sea lions are often attracted to boats (Richardson et al., 1995).

Based upon the above information regarding pinniped disturbance reactions, the Applicant anticipates that some pinnipeds may exhibit minor, short-term disturbance responses to underwater sounds from construction and sonar activities. Any potential impacts on pinniped behavior would be localized within the activity area and would not result in population-level effects.

7.3.4. Stress and Mortality

Marine mammal stranding or mortality would be highly unlikely to result from any of the proposed activities. Marine mammal strandings have been correlated with pulsed sounds produced during previous marine survey activities. The most likely potential cause of mortality to marine mammals from the proposed activities would be a ship strike. Trained observers aboard Project vessels are authorized to request mitigation measures, including reduction in vessel speed and course alteration, to minimize potential ship strikes. Given the above information, it is extremely unlikely that the proposed activities would result in stranding or mortality to marine mammals.

Although the proposed impulsive and continuous pile driving activities would operate for extended periods of time, this activity would be limited to Lower Cook Inlet (Nikiski) during the summer period when belugas, harbor seals, and harbor porpoises are concentrated in important feeding and breeding nearshore waters in upper Cook Inlet. Chronic exposure to these sound levels is not expected. Safety zones would be established to prevent acoustical injury to local marine mammals, especially injury that could indirectly lead to mortality. Also, impulsive sound is not expected to cause resonate effects to gas-filled spaces or airspaces in marine mammals based on the research of Finneran (2003) on beluga whales showing that the tissue and other body masses dampen any potential effects of resonance on ear cavities, lungs, and intestines. However, chronic exposure to impulsive sound could lead to physiological stress eventually causing hormonal imbalances (National Research Council [NRC], 2005). If survival demands are already high, and/or additional stressors are present, the ability of the animal to cope decreases leading to pathological conditions or death (NRC, 2005). Effects may be greatest where sound disturbance can disrupt feeding patterns, including displacement from critical feeding grounds.

Pipelay across Cook Inlet would occur near summer beluga concentration areas. The primary sound source would be the drive propeller and thruster cavitation during anchor handling, which extends about 4.25 kilometers (2.64 miles) to the 120-dB isopleth (Blackwell and Greene, 2003). Only low densities of summer beluga whales are expected along the planned route across Cook Inlet between June and August, as the landfall for this route is 6.0 kilometers (3.5 miles) south of the nearest beluga summer concentration area (Beluga River). However, based on previous marine mammal surveys (Nemeth et al., 2007; Brueggeman,

2007a, b) in the area, beluga whales are expected to occur in moderate or higher numbers in this area in May and October.

8. DESCRIPTION OF IMPACT ON SUBSISTENCE USES

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

8.1. Subsistence Uses

The proposed Marine Terminal construction activities would occur closest to the marine subsistence area used by Nikiski, while the offshore pipeline and Beluga Mainline MOF would occur within the subsistence use area used by Tyonek.

The Alaska LNG Project funded a study, conducted by the Alaska Department of Fish and Game (ADF&G), to document the harvest and use of wild resources by residents of communities on the east and west sides of Cook Inlet (Jones and Kostick, 2016). Data on wild resource harvest and use were collected, including basic information about who, what, when, where, how, and how much wild resources are being used to develop fishing and hunting opportunities for Alaska residents. Tyonek was surveyed in 2013 (Jones et al., 2015), and Nanwalek, Port Graham, Seldovia, and Nikiski were surveyed in 2014 (Jones and Kostick, 2016). Marine mammals were harvested by four (Nikiski, Seldovia, Nanwalek, Port Graham) of the five communities but at relatively low rates (Table 24). The harvests consisted of harbor seals, Steller sea lions (*Eumatopia jubatus*), and northern sea otters (*Enhydra lutris*).

Table 24: Marine Mammal Harvest by Tyonek in 2013 and Nikiski, Port Graham, Seldovia, and Nanwalek in 2014

Village	Harvest (pounds per capita)	Households Attempting Harvest number (% of residents)	Number of Marine Mammals Harvested			
			Harbor Seal	Steller Sea Lion	Northern Sea Otter	Beluga Whale
Tyonek	2	6 (6 %)	6	0	0	0
Nikiski	0	0 (0 %)	0	0	0	0
Seldovia	1	2 (1 %)	5	0	3	0
Nanwalek	11	17 (7 %)	22	6	1	0
Port Graham	8	27 (18 %)	16	1	24	0

8.1.1. Beluga Whale

The Cook Inlet beluga whale has traditionally been hunted by Alaska Natives for subsistence purposes. For several decades prior to the 1980s, the Native Village of Tyonek residents were the primary subsistence hunters of Cook Inlet beluga whales. During the 1980s and 1990s, Alaska Natives from villages in the western, northwestern, and North Slope regions of Alaska either moved to or visited the south-central region and participated in the yearly subsistence harvest (Stanek, 1994). From 1994 to 1998, NOAA Fisheries estimated 65 whales per year (range 21-123) were taken in this harvest, including those

successfully taken for food, and those struck and lost. NOAA Fisheries has concluded that this number is high enough to account for the estimated 14 percent annual decline in population during this time (Hobbs et al., 2008). Actual mortality may have been higher, given the difficulty of estimating the number of whales struck and lost during the hunts. In 1999, a moratorium was enacted (Public Law 106-31) prohibiting the subsistence take of Cook Inlet beluga whales except through a cooperative agreement between NOAA Fisheries and the affected Alaska Native organizations. Since the Cook Inlet beluga whale harvest was regulated in 1999 requiring cooperative agreements, five beluga whales have been struck and harvested. Those beluga whales were harvested in 2001 (one animal), 2002 (one animal), 2003 (one animal), and 2005 (two animals). The Native Village of Tyonek agreed not to hunt or request a hunt in 2007, when no co-management agreement was to be signed (NMFS, 2008).

Residents of the Native Village of Tyonek are the primary subsistence users in Knik Arm area. No households hunted beluga whale locally in Cook Inlet due to conservation concerns; however, beluga whale resources were received from other areas of Alaska by approximately 10 percent of households in 2013 (Jones et al., 2015). The Project should not have any effect because no beluga harvest has taken place since 2006, and beluga hunts are not expected during the ITR period.

8.1.2. Steller Sea Lion and Harbor Seal

The only non-listed marine mammal available for subsistence harvest in Cook Inlet is the harbor seal (Wolfe et al., 2009), while listed Steller sea lions are also occasionally taken. Marine mammals are harvested in low numbers in the communities closest to the Project area (Nikiski and Tyonek). Higher marine mammal harvest occurs in the communities that are not accessible by the road system of Seldovia, Nanwalek, and Port Graham (Table 25).

Table 25: Steller Sea Lion and Harbor Seal Harvest by Tyonek in 2013 and Nikiski, Port Graham, Seldovia and Nanwalek Communities in 2014

Community^a	Percent Harbor Seal Harvest	Total Harbor Seal Harvest in Pounds	Percent Households Using Harbor Seal	Percent Steller Sea Lion Harvest	Total Steller Sea Lion Harvest in Pounds	Percent Households Using Steller Sea Lion
Tyonek ^b	100 (100%)	360	14 (14%)	Not Harvested	Not Harvested	Not Harvested
Seldovia ^c	67 (67%)	300	1 (1%)	Not Harvested	Not Harvested	Not Harvested
Nanwalek ^c	50 (50%)	1,225.3	71 (71%)	50 (50%)	1,242.9	25 (25%)
Port Graham ^c	38 (28%)	1,154	27 (27%)	3 (3%)	282.0	7 (7%)

^a Nikiski is not included in this table; see discussion below on Nikiski harvest.

^b Tyonek information from Jones et al., 2015

^c Nikiski, Port Graham, Seldovia and Nanwalek information from Jones and Kostick, 2016

Jones and Kostick (2016) reported that 2 percent of households in Nikiski used harbor seals and 1 percent reported using unknown seal species (both gifted from another region). No marine mammals were

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 60

actively hunted by Alaska Native residents in Nikiski. There is limited use of marine mammals thought to be from the small number of Alaska Natives living in Nikiski (Jones and Kostick, 2016).

In Tyonek, harbor seals were harvested between June and September by 6 percent of the households (Jones et al., 2015). Seals were harvested in several areas, encompassing an area stretching 20 miles along the Cook Inlet coastline from the McArthur Flats north to the Beluga River. Seals were searched for or harvested in the Trading Bay areas as well as from the beach adjacent to Tyonek (Jones et al., 2015).

In Seldovia, the harvest of harbor seals occurred exclusively in December (Jones and Kostick, 2016).

In Nanwalek, 22 harbor seals were harvested in 2014 between March and October, the majority of which occur in April. Nanwalek residents typically hunt harbor seals and Steller sea lions at Bear Cove, China Poot Bay, Tutka Bay, Seldovia Bay, Koyuktolik Bay, Port Chatam, in waters south of Yukon Island, and along the shorelines close to Nanwalek, all south of the Project Area (Jones and Kostock, 2016).

According to the results presented in Jones and Kostick (2016) in Port Graham, harbor seals were the most frequently used marine mammal. Harbor seals were harvested in January, February, July, August, September, November, and December. Steller sea lions were used noticeably less and harvested in November and December.

8.1.3. Other Marine Mammals

There are no harvest quotas for other non-listed marine mammals found in Cook Inlet. The only data available for subsistence harvest of harbor porpoises, and humpback and killer whales in Alaska are in the marine mammal stock assessments. However, these numbers are for the Gulf of Alaska including Cook Inlet, and they are not indicative of the harvest in Cook Inlet. Jones et al. (2015) and Jones and Kostick (2016) did not report subsistence harvest in Tyonek, Nikiski, Seldovia, Port Graham, or Nanwalek of harbor porpoise or humpback and killer whales. Therefore, because the proposed program would result in only temporary disturbances, the construction project would not impact the availability of these other species for subsistence uses.

8.2. Potential Impacts on Availability for Subsistence Uses

Section 101(a)(5)(A) requires NOAA Fisheries to determine that the taking would not have an unmitigable adverse effect on the availability of marine mammal species or stocks for subsistence use. NOAA Fisheries has defined “unmitigable adverse impact” in 50 CFR 216.103 as an impact resulting from the specified activity: (1) That is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by: (i) Causing the marine mammals to abandon or avoid hunting areas; (ii) Directly displacing subsistence users; or (iii) Placing physical barriers between the marine mammals and the subsistence hunters; and (2) That cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

Construction activities for elements of the Project within waters of Cook Inlet, such as installation of the Mainline crossing of Cook Inlet and construction of the Marine Terminal at the Liquefaction Facility, could result in disturbances of marine mammals including beluga whales, harbor porpoises, and harbor seals

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 61

within the Project vicinity. Areas used by the residents of Seldovia, Port Graham, and Nanwalek are located more than 70 miles south of the proposed Marine Terminal, Mainline MOF, and Mainline crossing and outside the Project construction area and any associated zones of influence due to the generation of underwater sound during construction.

The Project’s planned Marine Terminal construction and Mainline pipe-laying activities would not impact marine mammals in sufficient numbers to render them unavailable for subsistence harvest. In addition, mitigation measures would be implemented to ensure protection of beluga habitat. Because of the short-term, temporary, and localized nature of construction activities, the Applicant concludes, based on all the analyses and information presented above, that impacts to any marine mammal harvest potential would be negligible. While Project activities would occur within the traditional area for hunting marine mammals, no relevant subsistence uses of marine mammals would be impacted by this action.

9. DESCRIPTION OF IMPACT ON MARINE MAMMAL HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

9.1. Potential Physical Impacts on Habitat

Construction would result in some seafloor disturbance and temporary increases in water column turbidity. Over time, scars from construction would be filled due to natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type.

9.1.1. Seafloor Disturbance

Three types of activities associated with construction would result in seafloor disturbance, dredging/trenching, disposal of dredged material, and facility installation. Approximately 42 hectares (103 acres) would be disturbed directly by dredging of the MOF and trenching for the Mainline crossing, and another 486 hectares (1,200 acres) would be disturbed by the disposal of dredged material. Approximately 26 hectares (64 acres) of seafloor would be disturbed by installation of the MOF, Mainline MOF, and Mainline Crossing (Table 26). Additional area would be indirectly affected by the re-deposition of sediments suspended in the water column by the dredging/trenching and dredge disposal.

Table 26: Seafloor Disturbance from Construction of the Marine Terminal and Mainline Crossing

Activity	Facility	Area Affected in hectares (acres)	Impact Duration
Dredging / Trenching	MOF	20.5 (50.7)	Temporary
	Mainline Crossing	^a 20.6 (51.0)	Temporary
	Shoreline Protection	0.6 (1.5)	Temporary
	Subtotal Dredging/Trenching	41.7 (103.2)	Temporary
Dredge Disposal	MOF	485.6 (1,200.0)	Temporary
	Subtotal Dredge Disposal	485.6 (1,200.0)	Temporary
Facility Installation	MOF	^b 11.5 (28.3)	Long-Term
	Mainline MOF	2.2 (5.5)	Permanent
	PLF	7.6 (18.7)	Permanent
	Mainline Crossing	^c 4.5 (11.0)	Permanent
	Subtotal Facility	20.3 (50.1)	-
Total		546.3 (1,350.4)	-

^a The seafloor disturbance from pipeline trenching could range from 11 to 21 hectares (26 to 51 acres) depending on terminal water depth and slope of the trench.

^b Approximately 6.9 hectares (16.98 acres) of the MOF is also included in the dredge area.

^c Represents the area of 42-inch-diameter pipe laying on the seafloor in the offshore un-trenched section of the route.

^d Temporary is 1–10 years, Long-Term is 10–30 years, and Permanent is > 30 years (life of Project).

Bottom sediments in the lower inlet are coarse gravel and sand that grade to finer sand and mud toward the south (Bouma et al., 1978). Coarser substrate support a wide variety of invertebrates and fish including Pacific halibut, Dungeness crab (*Metacarcinus magister*), tanner crab (*Chionoecetes bairdi*), pandalid shrimp (*Pandalus* spp.), Pacific cod, and rock sole (*Lepidopsetta bilineata*), while the soft-bottom sand and silt communities are dominated by polychaetes, bivalves and other flatfish (Field and Walker, 2003). Sea urchins (*Strongylocentrotus* spp.) and sea cucumbers are important otter prey and are found in shell debris communities. Razor clams (*Siliqua patula*) are found all along the beaches of the Kenai Peninsula. In general, the lower Cook Inlet marine invertebrate community is of low abundance, dominated by polychaetes, until reaching the mouth of the inlet (Saupe et al., 2005).

Secondary productivity at the seafloor of the Upper Cook Inlet is generally low. Fukuyama et al. (2012) sampled benthic invertebrates at 44 locations in Cook Inlet. Arthropoda, dominated by the amphipods *Ischyrocerus* sp. and *Photis* sp., comprised about 12 percent of the total. Mollusca (mostly the bivalves *Ennucula tenuis* and *Axinopsida serricata*) accounted for 8 percent, and miscellaneous taxa and Echinodermata accounted for <1 percent. Distinct biological communities were found in different portions of Cook Inlet with a strong north to south gradient of increasing species diversity observed. The Upper Cook Inlet was found to have much lower numbers of individuals and taxa, most likely due to the extreme physical conditions. These areas of extreme tidal currents, low salinity, and high turbidity regimes produce environments with low total organic carbon and sediment fines, resulting in suboptimal environments for diverse and productive infaunal communities.

The Applicant conducted some sampling for benthic infauna at five locations near the Marine Terminal and found similar results (Table 27). Abundance (number of individuals) and richness (number of taxa) were low, with 54 percent annelids, 24 percent crustaceans, and 2 percent molluscs.

Table 27: Benthic Infaunal Sampling Results Near Proposed Marine Terminal

Parameter	Sample Station ¹					
	1	2	3	4	5	All
Abundance ²	8	9	25	41	28	111
Mean Abundance	-	-	-	-	-	22
Taxa Richness ³	6	6	9	14	5	19
Mean Richness	-	-	-	-	-	8
Margalef's Index (SR)	2.40	2.28	2.49	3.50	1.20	3.82
Mean SR	-	-	-	-	-	2.37
Diversity H	2.53	2.42	2.82	3.64	2.03	3.74
Mean H	-	-	-	-	-	2.69
Evenness J	0.98	0.94	0.89	0.96	0.87	0.88
Mean J	-	-	-	-	-	0.93
Simpson's Index (SDV)	0.71	0.79	0.72	0.87	0.59	0.84
Mean SDV	-	-	-	-	-	0.74

¹ Samples collected in May 2016 in MOF dredge area, with 0.1 square meter KC Day sampler, an sieved with 0.5-mm mesh screen, one sample per station

² Number of organisms in a 0.1 m² sample, range (mean)

³ Organisms per square meter, range (mean)

⁴ Number of unique taxonomic classifications within the sample, range (mean)

⁵ Margalef's species richness index, range (mean)

⁶ Pielou index to species evenness J', range (mean)

⁷ Shannon-Weiner index to diversity, range (mean)

⁸ Simpson's diversity index SDV, range (mean)

Source: MTS 2016

Organisms in the areas that would be disturbed by construction of the Project are adapted to the high-energy environment. They would be removed or killed through excavation or burial; however, re-colonization would be expected to occur relatively quickly. No areas of higher productivity such as razor clam beds, kelp, or eelgrass beds are known to occur in or near the Marine Terminal Area, along the Mainline route, or in the dredge disposal areas.

9.1.2. Water Quality Disturbance

The primary effects on water quality from construction of the Project in Cook Inlet would be the temporary suspension of sediment in the water column from dredging, trenching, and dredge disposal. The Project would also result in the discharge of hydrostatic test waters, and 2) normal vessel discharges from construction vessels, including deck drainage (runoff of precipitation and deck wash water), ballast water, bilge water, non-contact cooling water, and gray water.

9.1.2.1. Water Quality Disturbance from Dredging/Trenching

Dredging operations during construction of the temporary MOF would cause a temporary, localized increase in turbidity and sedimentation in the marine waters of Cook Inlet. Turbidity and sedimentation rates are naturally high in the Upper Cook Inlet due to the abundance of glacial sediments and strong currents. High suspended sediment concentrations characterize the entire Upper Cook Inlet, with sediment loads increasing between the Forelands, at approximately 100–200 parts per million (ppm), to

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 64

the Anchorage area at the head of the inlet, at levels greater than 2,000 ppm. Annual suspended-sediment load to Cook Inlet is more than 44 million tons (USGS, 1999). High local tidal currents tend to keep this sediment suspended. Soils within Cook Inlet consist of silts, sands, granular material, cobbles, and boulders—all can be moved by the tidal fluctuations (USEPA, 2002). Additional mobilization of sediment is not anticipated to have significant impact.

Several disposal and/or reuse options are under consideration. The preferred disposal site for dredged materials is an offshore unconfined aquatic disposal site located within 8 kilometers (5 miles) of the dredged area, with water depths greater than 24 meters (80 feet) and dispersive currents. The expected method of dredge disposal would be a split hull barge over the disposal site. The strong tidal currents of Cook Inlet would naturally disperse the sediment from the disposal site. Disposal of dredged sediments would cause a localized, short-term increase in turbidity and sedimentation near the disposal site for the duration of disposal activities. Currents would be expected to rapidly entrain and remobilize any sediment deposited.

9.1.2.2. Water Quality Disturbance from Hydrostatic Testing

Approximately 10 million gallons of Cook Inlet seawater would be required to conduct hydrostatic testing of the offshore segment of the Mainline. After use, the hydrostatic test water would be discharged back to Cook Inlet according to regulatory requirements and permit conditions. The discharge would be permitted with the Alaska Department of Environmental Conservation (ADEC) under its Alaska Pollutant Discharge Elimination System (APDES), and would be conducted in a manner that meets all regulatory requirements.

Because Cook Inlet would be the water source and the pipe in which the water has been held would be on the Cook Inlet seafloor, there would be little difference in the physical characteristics of the discharge water and the receiving water body such as temperature and salinity. Because Cook Inlet is a high-energy system with strong currents, extreme tides, and short tidal exchange rate, the discharge would mix quickly and have few if any noticeable effects on ambient waters.

9.2. Potential Impacts on Food Sources from Sound Generation

9.2.1. Zooplankton

Zooplankton is a food source for several marine mammal species, including humpback whales, as well as a food source for fish are then prey for marine mammals. Population effects on zooplankton could therefore have indirect effects on marine mammals. The primary generators of sound energy associated with construction of the Project include anchor handling and vessel docking, dredging, and pile driving. Popper and Hastings (2009) 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 man-made sound would have physiological effects on invertebrates. Any such effects would be limited to the area very near (1–5 meters [3.2–16.4 feet]) the sound source and would result in no 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).

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 65

No adverse impact on zooplankton populations would be expected to occur from pile driving, 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, as these activities produce much lower sound energy levels.

9.2.2. Benthos

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 operations is negligible compared to the naturally occurring high reproductive and mortality rates.

9.2.3. Fish

Fish have been shown to react when engine and propeller sounds exceeds a certain level (Olsen et al., 1983; Ona, 1988; Ona and Godo, 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110–130 dB re 1 μ Pa rms (Nakken, 1992; Olsen, 1979; Ona and Godo, 1990; Ona and Toresen, 1988). Vessel sound source levels in the audible range for fish are typically 150–170 dB re 1 μ Pa/Hz (Richardson et al., 1995). The construction vessels during anchor handling and docking would be expected to produce levels of 170–175 dB re 1 μ Pa rms when in transit. Based upon the reports in the literature and the predicted sound levels from these vessels, there may be some avoidance by fish in the immediate area.

Pile driving has more potential to affect fish given the higher source levels and rapid rise times. Fish with swim bladders are particularly sensitive to underwater impulsive sounds due to swim bladder resonance; as the pressure wave passes through a fish, the swim bladder is rapidly squeezed as the high-pressure wave, and then under pressure component of the wave, passes through the fish. The swim bladder may repeatedly expand and contract at the high SPL, creating pressure on the internal organs surrounding the swim bladder. There have been several thorough reviews of the literature on the effects of pile driving on fish (Hastings and Popper, 2005; Popper and Hastings, 2009). The Fisheries Hydroacoustic Working Group (2008) provided criteria agreed to by the Federal Highway Administration, NOAA Fisheries, USFWS, and various state agencies. Another working group (Popper et al., 2014) provided the guidelines in Table 28.

Table 28: Guidelines for Assessing Acoustical Impacts to Fish from Pile Driving

Type of Fish	Mortality and Potential Mortal Injury	Recoverable Injury	TTS	Masking	Behavior
No swim bladder	>219 dB SEL _{cum} or >213 dB _{peak}	>216 dB SEL _{cum} or >213 dB _{peak}	>>186 dB SEL _{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Swim bladder not involved in hearing	210 dB SEL _{cum} or >207 dB _{peak}	203 dB SEL _{cum} or >207 dB _{peak}	186 dB SEL _{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Swim bladder involved in hearing	207 dB SEL _{cum} or >207 dB _{peak}	203 dB SEL _{cum} or >207 dB _{peak}	186 dB SEL _{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate

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 (93–135 millimeters) at two distance ranges (near 1.8–6.7 meters and distant 15 meters) to 0.5-meter-diameter steel piles driven with a vibratory hammer. Sound pressure levels reached 208 dB re 1 μ Pa peak, 194 dB re 1 μ Pa rms, and 179 dB re 1 μ Pa² s SEL, leading to a cumulative SEL of approximately 207 dB re 1 μ Pa² 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 (86–124 millimeters, 10–16 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 μ Pa peak, and cumulative SEL sound pressures ranging from 179.2 to 190.6 dB re 1 μ Pa² s. 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.

The California Department of Transportation (Caltrans, 2010) exposed juvenile steelhead (*Onchorhynchus mykiss*) to a variety of peak SPLs and SELs at various distances (35–150 meters) from driving 2.2-meter-diameter cast-in-steel-shell piles driven immediately adjacent to the Mad River. Peak SPLs ranged from 69–188 dB re 1 μ Pa and cumulative SELs ranged from 179–194 dB re 1 μ Pa² s. No physical trauma was observed. Hematocrit and plasma cortisol levels were not significantly related to exposure to sound generated by pile driving.

Vessel docking and anchor handling are likely to have no more effect on fish than temporary habitat displacement/avoidance while the activity is conducted. Information in the literature indicates that pile driving could potential result in injury or mortality to fish, but the results of *in situ* studies on salmonids indicates that such effects are unlikely. Any such effects would be minor given the size of the Cook Inlet and the area that would be affected.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 67

9.3. Invasive Species

Vessels can impact habitat quality for marine mammals through the introduction of aquatic invasive organisms. Construction vessel traffic would arrive from Asia and could potentially transport non-native tunicates, green crab (*Carcinus maenas*), and Chinese mitten crab (*Eriocheir sinensis*) (ADF&G, 2002), which impact food webs and can outcompete native invertebrates, resulting in habitat degradation.

All vessels brought into the State of Alaska or federal waters are subject to United States Coast Guard (USCG) 33 CFR 151 regulations, which are intended to reduce the transfer of aquatic invasive organisms. Management of ballast water discharge is regulated by federal regulations (33 CFR 151.2025) that prohibit discharge of untreated ballast water into the waters of the United States unless the ballast water has been subject to a mid-ocean ballast water exchange (at least 200 nautical miles offshore). Vessel operators are also required to remove “fouling organisms from hull, piping, and tanks on a regular basis and dispose of any removed substances in accordance with local, state, and federal regulations” (33 CFR 151.2035(a)(6)). Adherence to the USCG 33 CFR 151 regulations would reduce the likelihood of Project-related vessel traffic introducing aquatic invasive species.

9.4. Potential Impacts from Habitat Contamination

9.4.1. Petroleum Release

Large and small quantities of hazardous materials, including diesel fuel and gasoline, would be handled, transported, and stored following the rules and procedures described in the Spill Prevention, Control, and Countermeasure (SPCC) Plan. Spills and leaks of oil or wastewater arising from the Project activities that reach marine waters could result in direct impacts to the health of exposed marine mammals. Individual marine mammals could show acute irritation or damage to their eyes, blowhole or nares, and skin; fouling of baleen, which could reduce feeding efficiency; and respiratory distress from the inhalation of vapors (Geraci and St. Aubin, 1990). Long-term impacts from exposure to contaminants to the endocrine system could impair health and reproduction (Geraci and St. Aubin, 1990). Ingestion of contaminants could cause acute irritation to the digestive tract, including vomiting and aspiration into the lungs, which could result in pneumonia or death (Geraci and St. Aubin, 1990).

Indirect impacts from spills or leaks could occur through the contamination of lower-trophic-level prey, which could reduce the quality and/or quantity of marine-mammal prey. In addition, individuals that consume contaminated prey could experience long-term effects to health (Geraci and St. Aubin, 1990).

9.4.2. Contamination and Waste

Construction-generated waste is not to affect marine mammals due to discharges being into sediment basins and water testing requirements. To prevent and mitigate against inadvertent contamination from waste, all waste storage areas should occur in upland areas and be properly contained until disposal. Impacts to marine mammals that are directly related to waste and waste disposal are not anticipated.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 68

10. DESCRIPTION OF IMPACT FROM LOSS OR MODIFICATION TO HABITAT

The anticipated impact of the loss or modification of habitat on the marine mammal populations involved.

In addition to noise impacts, marine mammal habitat could be affected by Project activities including habitat modification from dredging and spoil disposal activities, or impairment from incidental or accidental spills. Project activities that could potentially impact marine mammal habitats include temporary disturbance primarily through increases in underwater SPLs from pile driving and vessel propeller/thruster operation, and temporary habitat loss from dredging. The primary effect from pipelay might be permanent displacement of mobile benthic resources, such as crabs. However, Upper Cook Inlet supports a low abundance and diversity of marine invertebrates (Saupe et al., 2005).

Five major rivers (Knik, Matanuska, Susitna, Little Susitna, and Beluga) deliver freshwater to Upper Cook Inlet, carrying a heavy annual sediment load of over 40 million tons of eroded materials and glacial silt (Brabets, 1999). As a result, Upper Cook Inlet is relatively shallow, averaging 18 meters (60 feet) in depth. A deep trough exists between Trading Bay and the Middle Ground Shoal, ranging from 64 to 140 meters (210 to 460 feet) deep (NOAA Nautical Chart 16660). The substrate consists of a mixture of coarse gravels, cobbles, pebbles, sand, clay, and silt (Bouma et al., 1978; Rappeport, 1982). Upper Cook Inlet experiences some of the most extreme tides in the world, as demonstrated by a mean tidal range from 4 meters (13 feet) at the Gulf of Alaska end to 28.8 feet near Anchorage (United States Army Corps of Engineers [USACE], 2013). Tidal currents reach 6.6 feet/second (3.9 knots) (Mulherin et al., 2001) in upper Cook Inlet, increasing to 9.8 to 13 feet/second (5.7 to 7.7 knots) near the Forelands where the inlet is constricted. Each tidal cycle creates significant turbulence and vertical mixing of the water column in the upper inlet (USACE, 2013), and are reversing, meaning that they are marked by a period of slack tide followed an acceleration in the opposite direction (Mulherin et al., 2001). Because of scouring, mixing, and sediment transport from these currents, the marine invertebrate community is very limited (Pentec, 2005). Of the 50 stations sampled by Saupe et al. (2005) for marine invertebrates in Southcentral Alaska, their Upper Cook Inlet station had, by far, the lowest abundance and diversity. Furthermore, the fish community of Upper Cook Inlet is characterized largely by migratory fish—eulachon and Pacific salmon—returning to spawning rivers, or out-migrating salmon smolts. Moulton (1997) documented only 18 fish species in Upper Cook Inlet compared to at least 50 species found in lower Cook Inlet (Robards et al., 1999).

Fish are a primary dietary component of the odontocete and pinniped species in Cook Inlet. Impact driving of steel piles can produce sound pressure waves that can injure and kill small fish (multiple sources as cited in NMFS 2005). Impacts of proposed pile driving are addressed further in the Essential Fish Habitat Assessment. In contrast to pile driving, vibratory pile driving does not produce the same percussive sound waves that are harmful to fish and has not resulted in any known fish kills (USFWS, 2004), and has been employed in Puget Sound partially as a mitigation measure to limit effects to fish. Vibratory hammer studies by Carlson (1996) in Oregon and Nedwell et al. (2003) in the United Kingdom have confirmed that fish are little impacted by this hammering method.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 69

Short-term turbidity is a water quality effect of most in-water work, including installing piles. A study conducted during pile driving measured water quality before, during, and after pile removal and pile replacement (Roni and Weitkamp, 1996) and found that construction activity at the site had “little or no effect on dissolved oxygen, water temperature, and salinity”, and turbidity (measured in nephelometric turbidity units [NTU]) at all depths nearest the construction activity was typically less than 1 NTU higher than stations farther from the construction area throughout construction. None of the marine mammals are expected to be close enough to the pile driving activity to experience turbidity. Coupled with the fact that Cook Inlet currently carries a heavy sediment load naturally in the water column, the impact from increased turbidity levels is expected to be discountable to marine mammals.

Dredging and dredge spoil placement would temporarily impact the benthic resources within the dredging and spoils footprint. However, few benthic resources are expected where the dredging would occur. The footprint of the pipelay on the Cook Inlet seafloor and the Marine Terminal facilities is less than 1 percent of the Beluga Critical Habitat Zone 2 area.

10.1. Beluga Whale Habitat

Beluga Critical Habitat could be impacted by Project activities. When establishing critical habitat for the Cook Inlet beluga whale, NOAA Fisheries identified the following as the Primary Constituent Elements (PCEs); an analysis of the potential effects of the survey program on these elements follows.

10.1.1. Intertidal and Subtidal Waters of Cook Inlet

The shore crossing of the Mainline on the west side of Cook Inlet is located within 8 kilometers (5 miles) of several anadromous streams (Three-mile Creek, Indian Creek, and two unnamed streams). The shore crossing of the Mainline on the east side of Cook Inlet is also located within 8 kilometers (5 miles) of an anadromous stream (Bishop Creek). The Marine Terminal is located more than 8 kilometers (5 miles) from any anadromous stream. Construction of the shore crossings could potentially displace belugas from the areas around the mouths of these streams due to the vessel activity and associated underwater sound. Trenching for the nearshore sections would result in increased suspended sediment load in the water column, but any such effects would be minor, likely restricted to the area within 61 meters (200 feet) of the trenching activity. Trenching would result in the destruction and burial of benthic invertebrates in the footprint of the trench and any anchor scars. Benthic communities are generally sparse in Cook Inlet and adapted to the high-energy environment. The seafloor habitat would be re-colonized by a similar community. Any effects would be temporary and minor given the amount of available habitat of this type within Cook Inlet.

10.1.2. Primary Prey Species

Construction of the Marine Terminal, pipelay, and construction vessel traffic would not be expected to have an effect on the beluga prey species (Pacific salmon, Pacific eulachon, Pacific cod, saffron cod, yellowfin sole) by the sound generated by pile driving or anchor handling, physical disturbance of the fish habitat, or discharges associated with vessels. Any acoustical effects to beluga prey resources would be negligible, if they were to occur.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 70

10.1.3. Toxins or Other Agents Harmful to Beluga Whales

Small volumes of drilling mud associated with the geotechnical borings would be discharged to Cook Inlet; however, the drilling mud consists of ambient seawater and guar gum, a non-toxic polysaccharide commonly used as a food additive. These Project components would have no effect.

10.1.4. Unrestricted Passage Within or Between Critical Habitat Areas

Belugas may avoid areas where construction and pipelay activities would occur in Cook Inlet because of vessel activity, sound generated by the vessel traffic, dredging, trenching, pipelay, and increased turbidity. These activities would be conducted in open areas of Cook Inlet within Critical Habitat Area 2. Given the size and openness of Cook Inlet in the survey areas, and the small area and mobile/temporary nature of the zones of ensonification, the activities would not be expected to result in any restriction of passage of belugas within or between critical habitat areas. The program would have no effect on this PCE.

10.1.5. In-Water Noise at Levels and Cook Inlet Beluga Whale Habitat

Operation of the construction and pipelay equipment would generate sound with frequencies within the beluga hearing range and at levels above threshold values, and may result in temporary displacement of belugas. The greatest potential for such effects rests with the operation of vibratory or impact pile drivers at the Marine Terminal and anchor handling associated with Mainline trenching and pipelay. However, these effects are not likely to diminish the value of the PCE of the critical habitat for the conservation of Cook Inlet beluga whales. Whale movements between and among habitat areas are not likely to be impeded and the quantity and quality of prey are unlikely to be diminished. Impacts from sound energy are temporary, lasting only if the activity is being conducted. The areas of ensonification for received sound levels exceeding NOAA Fisheries thresholds for Level B harassment of marine mammals are provided in Section 6. These areas represent small portions of the critical habitat area within Critical Habitat Area 2. This is the area in which beluga whales expand their spring-summer distribution during the late fall and winter months, and the area into which the beluga whale population will expand as it recovers. Water quality may occasionally be affected by small infrequent spills at the Marine Terminal that would have only minor and transitory effects on water quality, and larger spills associated with a catastrophic release of fuel oil or other contaminants are so unlikely as to be discountable.

In 2011, after designation of critical habitat for Cook Inlet beluga whales, NOAA Fisheries issued a Biological Opinion (BiOp) analyzing the effects of the Port of Anchorage Marine Terminal Redevelopment Project (MTRP) on critical habitat. Although the Port of Anchorage was excluded from the critical habitat designation pursuant to section 4(b)(2) of the ESA, the action area for the MTRP extended beyond the exclusion into areas that are designated. Despite the exclusion, NOAA Fisheries analyzed the effect of the MTRP on the PCE values of habitat in the excluded area as well. NOAA Fisheries found the values of shallow water foraging habitat, prey species abundance and availability, absence of toxins and other harmful agents, and unrestricted passage within and between areas were not likely to be affected by dredging, filling, or construction activities in the action area (including the excluded port areas). NOAA Fisheries determined only the value “absence of in-water noise at levels resulting in the abandonment of habitat (PCE 5)” had the potential to adversely affect Cook Inlet belugas. In assessing the effect of the

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 71

action on that value, NOAA Fisheries determined that construction and operation of the expanded Port would introduce significant sound in the waters of Knik Arm. After review of available information on sources of noise, intensity and duration, and beluga responses, NOAA Fisheries concluded: “It is unlikely that belugas would alter their behavior in a way that prevents them from entering and/or transiting through Knik Arm causing abandonment of critical habitat.” Further, NOAA Fisheries’ BiOp concluded that the action, as proposed, is not likely to destroy or adversely modify Cook Inlet beluga whale critical habitat. Although this conclusion may indicate that the habitat is adversely affected, it is NOAA Fisheries’ opinion that critical habitat will remain functional and able to serve its intended conservation role for Cook Inlet beluga whales. Therefore, the Project is not likely to adversely modify critical habitat for the Cook Inlet beluga whale.

11. MEASURES TO REDUCE IMPACTS TO MARINE MAMMALS

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

11.1. Mitigation Measures

The activities of most concern regarding noise harassment to marine mammals include vibratory and impact pile driving. Pile driving is considered a discreet, non-routine action with the potential for Level A harassment. Anchor handling is of short duration and allows ample time for marine mammals to move away from the stimulus. Implementation of mitigation measures for anchor handling, such as shutdown zones, is impractical because to ensure safety and sound constructability of the pipeline, the process cannot be stopped once it has begun. Thus, mitigation measures are focused on pile driving. The Applicant may perform an SSV at the beginning of the pile driving to characterize the sound levels associated with different pile and hammer types, as well as to establish the marine mammal monitoring and mitigation zones.

The Mainline crossing of Cook Inlet has been routed to the greatest extent practicable, outside of Critical Habitat Area 1 to minimize effects on Cook Inlet beluga whales and critical habitat. All Contractors would comply with the Project’s SPCC Plan (Resource Report No. 2, Appendix M).

The primary means of minimizing impacts to marine mammals include:

1. Establishing shutdown safety zones for pile driving to ensure marine mammals are not injured by noise levels exceeding Level A injury thresholds.
2. Establishing shutdown safety zones for pile driving to ensure listed marine mammals are not injured by noise levels exceeding Level B injury thresholds.
3. Ensuring the observation area is clear of marine mammals before starting.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 72

4. Soft starting the impact hammer (low energy initial strikes), thereby alerting marine mammals of impending hammering noise and allowing them to vacate the general area before they become exposed to harassing sound levels.

Measures detailed in the *Project Waste Management Plan* provided in Resource Report No. 8, Appendix J, would be implemented, including:

- Proper handling and disposal of any food wastes including use of bear-proof dumpsters at Project locations.
- Proper handling, removal, and disposal of any animal carcasses.
- Management procedures for the control and containment of waste containers and food.

Measures in a *Marine Mammal Mitigation and Monitoring Plan* provided in Resource Report No. 3, Appendix N, would be implemented for noise and activity associated with construction activities and anchor handling.

All Project-related vessels would comply with USCG 33 CFR 151 for ballast water discharge.

Oil spill response plans for vessel groundings or other accidental releases of oil would be implemented.

11.1.1. Protected Species Observers

Protected Species Observers (PSOs) would be used during anchor handling activities to identify any marine mammals that may come into proximity of these activities. PSOs would be used for monitoring of marine mammals during anchor handling procedures, which cannot be stopped once the activity has started due to the need to ensure safety and sound constructability of the pipeline. During pile driving, PSOs would be given the authority to immediately stop construction and/or lower sound levels when marine mammals are visible within the various acoustic zones. The location of the PSOs would be determined based on the best vantage point, but would likely be stationed on land near the pile driving activity. Shutdown and Harassment Zones for Pile Driving

- The Applicant is proposing a 100-meter shut down zone for all pile driving operations to prevent Level A take by injury.
- The Applicant is proposing a 2.2 km Level B harassment zone for impact pile driving operations based on the calculated distance to the 160 dB threshold for pipe piles.
 - This zone would be used for potential Level B exposures for all marine mammals, other than beluga whales.
 - This zone would be used as the shut down zone for beluga whales.
- The Applicant is proposing a 4.6 km Level B harassment zone for all vibratory pile driving operations based on the calculated distance to the 120 dB threshold for sheet piles¹.

¹ The Applicant acknowledges the calculated distance to the 120 dB threshold for vibratory pile driving of pipe piles is 21.5 km. It is not feasible to monitor this zone, so the proposed zone is based on the calculated distance for

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
	Public	Revision: 3
		February 20, 2018
		Page 73

- This zone would be used for potential Level B exposures for all marine mammals, other than beluga whales.
- This zone would be used as the shut down zone for beluga whales.

Shutdown and Harassment Zones for Anchor Handling

- For safety reasons, it is not possible to stop handling anchors once the activity has started, so there would be no shutdowns.
- The Applicant is proposing a 2 km Level B harassment zone for anchor handling operations based on the calculated distance to the 120 dB threshold.
 - This zone would be used for potential Level B exposures for all marine mammals.

12. MEASURES TO REDUCE IMPACTS TO SUBSISTENCE USERS

Where the proposed activity would take place in or near a Traditional Arctic Subsistence Hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

Regulations at 50 CFR 216.104(a)(12) require applicants for activities that take place in Arctic waters to provide a Plan of Cooperation or information that identifies what measures have been taken and/or would be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. NOAA Fisheries regulations define Arctic waters as waters above 60° N latitude. Much of Cook Inlet is north of 60° N latitude.

NOAA Fisheries makes distinctions between waters in in Cook Inlet and waters of the Chukchi Sea and Beaufort Sea, more commonly thought of as Arctic (above the Arctic Circle). Because the level of subsistence hunting of marine mammals in Cook Inlet is low, a detailed Plan of Cooperation is not provided as part of this petition. Additionally, Tribal members from Seldovia, Port Graham, and Nanwalek are located more than 70 miles south of the proposed Project Area. The community of Nikiski reported low subsistence harvests (Jones and Kostick, 2016) and Tyonek’s distance to the Project Area is thought to minimize impacts to subsistence harvest.

The Applicant has met and would continue to meet with stakeholders throughout Cook Inlet, including many of the villages and traditional councils throughout the Cook Inlet region. The Applicant has identified the following features that are intended to reduce impacts to subsistence users:

- In-water activities would follow mitigation procedures to minimize effects on the behavior of marine mammals and, therefore, opportunities for harvest by Alaska Native communities.

vibratory pile driving of sheet piles. Further, the species of greatest concern, beluga whales, occur within 2 km of shore (Goetz et al. 2012), so the proposed zone of 4.6 km is feasible and biologically appropriate.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 74

13. MONITORING AND REPORTING

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity.

During the Project, the Applicant proposes to implement a marine mammal monitoring and mitigation strategy that would reduce impacts to marine mammals to the lowest extent practicable. The monitoring plan includes two general components, acoustic measurements and visual observations. The Applicant would develop a detailed Marine Mammal Monitoring and Mitigation Plan for this Project each year. Standard monitoring mechanisms are summarized in this section. The Marine Mammal Monitoring and Mitigation Plan would be implemented during all in-water activities.

13.1. Sound Source Verification

The Applicant may perform a sound source verification (SSV) survey for each pile and hammer type and during anchor handling to determine acoustic monitoring for impact pile driving to determine the actual distances to the 160 dB re 1µPa rms isopleths, which are used by NOAA Fisheries to define the Level B harassment zone for marine mammals for impact pile driving. The Applicant may 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.

13.2. Protected Species Observations

The Applicant would collect data on marine mammal sightings and any behavioral responses to in-water pile driving for species observed during activities associated with the Project. All PSOs would be trained in marine mammal identification and behaviors. Observations would occur at the best available and practicable vantage point to monitor the Level A and B harassment zones for marine mammals. The PSOs would have no other construction-related tasks or responsibilities while conducting monitoring for marine mammals.

Trained PSOs would be responsible for monitoring the EZ and SZ (see section 11) and calling for shutdown. They would 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 Project area and correlate those data with construction activities.
3. Report on observed reactions of beluga whales and other marine mammals in terms of behavior and movement during each sighting. These observers would monitor for beluga whales and all other marine mammals during all pile driving activities. These observers would work in collaboration with

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 75

the Applicant to immediately communicate any presence of marine mammals in the area prior to or during pile driving.

13.3. Reporting

A comprehensive annual marine mammal monitoring report documenting marine mammal observations would be submitted to NOAA Fisheries at the end of the in-water work season. A draft report including data collected and summarized from all monitoring locations would be submitted to NOAA Fisheries within 90 days of the completion of marine mammal monitoring. The report would include marine mammal observations (pre-activity, during-activity, and post-activity) during pile driving days. The results would be summarized in graphic form and include summary statistics and time histories of impact sound values for each pile. A final report would be prepared and submitted to NOAA Fisheries within 30 days following receipt of comments on the draft report from NOAA Fisheries.

Observers would collect marine mammal and other observations before and during pile driving activities including, at minimum:

- General data:
 - Date and time of activity.
 - Water conditions (e.g., sea-state).
 - Weather conditions (e.g., precipitation, percent glare, visibility).
- Specific pile-driving data:
 - Description of the pile driving activities including the size and type of pile.
 - The installation methods used for each pile and the duration each method was used per pile.
 - Impact or vibratory hammer force used to drive piles.
- Pre-activity and during activity observational data:
 - Date and time survey is initiated and terminated.
 - Description of any observable marine mammal behavior within monitoring zones or in the immediate area surrounding the monitoring zones, including the following:
 - Distance from animal to pile driving sound source.
 - Reason why shutdown implemented.
 - If a shutdown was implemented, behavioral reactions noted and if they occurred before or after implementation of the shutdown.
 - If a shutdown is implemented, the distance from animal to sound source at the time of the shutdown.
 - Distance and direction to the animal from the source during soft start.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 76

- Times when pile driving or other in-water construction is delayed due to weather conditions, presence of marine mammals within shutdown zones, etc.
- Actions performed to minimize impacts to marine mammals.
- Post-activity processing of data:
 - Results, which include the detections of marine mammals, the species and numbers observed, sighting rates and distances, behavioral reactions within and outside of safety zones.
 - Refined exposure estimate based on the number of marine mammals observed during construction.

14. RESEARCH COORDINATION

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

To minimize the likelihood that impacts would occur to the species, stocks, and subsistence use of marine mammals, all Project activities would be conducted in accordance with all federal, state, and local regulations. The Applicant would cooperate with other marine mammal monitoring and research programs taking place in Cook Inlet to coordinate research opportunities when feasible. The Applicant would also assess mitigation measures that can be implemented to eliminate or minimize any impacts from these activities.

Marine mammal monitoring would be conducted to collect information on presence of marine mammals within the disturbance and injury zones for this Project. Results of monitoring efforts from the Project would be provided to NOAA Fisheries 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 NOAA Fisheries. The monitoring data would inform NOAA Fisheries and future permit applicants about the behavior and adaptability of pinnipeds and cetaceans for future projects of a similar nature.

Prior to the start of the start of the Project each year, the Applicant would identify other monitoring programs in Cook Inlet so that information on species sightings can be shared among programs to minimize impacts. The Applicant is aware of scientific research programs that would be occurring in Cook Inlet in 2018, including two new recent ADF&G grants for continuing acoustic monitoring and photo identification of Cook Inlet beluga whales.

15. REFERENCES

- Alaska Department of Fish and Game (ADF&G). 2002. Alaska aquatic nuisance species management plan Available online at: <http://www.adfg.alaska.gov/FedAidPDFs/RIR.5J.2002.10.pdf> . Accessed October 3, 2015.
- Allen, B.M. and R.P. Angliss. 2014. Alaska marine mammal stock assessments, 2013. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-277, 294 p.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 77

- Allen, B. M., and R. P. Angliss. 2015. Alaska marine mammal stock assessments, 2014. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS AFSC-301, 304 p. doi:10.7289/V5NS0RTS.
- Awbrey, F.T., J.A. Thomas, and R.A. Kasetelein. 1988. Low frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. Journal of the Acoustical Society of America 84:2273-2275.
- Barlow J. 1988. Harbor porpoise, *Phocoena*, abundance estimation for California, Oregon, and Washington: I. Ship surveys. Fishery Bulletin 86:417-432.
- Barlow, Jay, J. Calambokidis, E.A. Falcone, C.S. Baker, A.M. Burdin, P.J. Clapham, and J.K.B. Ford. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science 27:793-818.
- Blackwell, S. B. 2005. Underwater measurements of pile-driving sounds during the Port MacKenzie dock modifications, 13-16 August 2004. Prepared for Knik Arm Bridge and Toll Authority by Greeneridge Sciences, Inc. and LGL Alaska Research Associates, Inc., at the request of HDR Alaska, Inc. Goleta, CA.
- Blackwell, S.B. and C.R. Greene, Jr., 2003. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Greeneridge Rep. 271-2. Revised June 2003. Prepared by Greeneridge Sciences, Inc., Santa Barbara, Calif., for National Marine Fisheries Service, Anchorage.
- Bouma, A.H., M.A. Hampton, J.W. Whitney, and W.G. Noonan. 1978. Physiography of Lower Cook Inlet, Alaska. U.S. Geological Survey Open-File Report 78-728.
- Boveng, P.L., J.M. London, and J.M. VerHoef. 2012. Distribution and abundance of harbor seals in Cook Inlet, Alaska. Task III: Movements, marine habitat use, diving behavior, and population structure, 2004-2006. Final Report. BOEM Report 2012-065. BOEM, Alaska OCS Region, Anchorage, AK. 58 pp.
- Brabets et al. 1999. Water-Quality Assessment of the Cook Inlet Basin, Alaska – Environmental Setting. U.S. Geological Survey Water-Resources Investigations Report 99-4025.
- Brueggeman, J. J., M. Smultea, H. Goldstein, S. McFarland, and D. J. Blatchford. 2007a. 2007 spring marine mammal monitoring program for the ConocoPhillips Beluga River seismic operations in Cook Inlet Alaska: 90-day report. Prepared by Canyon Creek Consulting for ConocoPhillips Alaska, Inc.
- Brueggeman, J. J., M. Smultea, K. Lomac-MacNair, D. J. Blatchford, and R. Dimmick. 2007b. 2007 fall marine mammal monitoring program for the Union Oil Company of California Granite Point seismic operations in Cook Inlet Alaska: 90-day report. Prepared by Canyon Creek Consulting for Union Oil Company of California.
- California Department of Transportation (Caltrans). 2010. Mad River bridges replacement project: effects of pile driving sound on juvenile steelhead. Clatrans, Eureka, CA. 22 pp.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 78

- Calkins D.G. 1989. Status of beluga whales in Cook Inlet. Pp. 109-112 in Jarvela L.E., Thorsteinson L.K. (eds) Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, Anchorage, AK, Feb. 7-8. U.S. Dept. Commerce, NOAA, OCSEAP, Anchorage, AK.
- Carlson, T.J. 1996. The Characterization of Underwater Infrasound Generated by Vibratory Pile Driving Within the Context of the Characteristics of Sound Known to Result in Avoidance Response by Juvenile Salmonids. Thesis. Oregon State University. 17 pp.
- Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. Marine Mammal Science 16:28-45.
- Di Iori, L. and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology letters 6:51-54. <http://rsbl.royalsocietypublishing.org/content/roybiolett/6/1/51.full.pdf>
- Field, C. and C. Walker. 2003. Kachemak Bay Research Reserve, a unit of the National Estuarine Research Reserve System: A site profile of the Kachemak Bay Research Reserve. Homer, AK.
- Finneran, J.J. 2003. Whole-lung response in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). J. Acous. Soc. 114:529-535.
- Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111:2929-2940.
- Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. J. Acoust. Soc. Am. 118(4):2696-2705.
- Finneran, J.J., D. A. Carder, R. Dear, T. Belting, J. McBain, L. Dalton, and S. H. Ridgway. 2005. Pure tone audiograms and possible aminoglycoside-induced hearing loss in belugas (*Delphinapterus leucas*). Journal of Acoustical Society of America 117:3936-3943.
- Fisheries Hydroacoustic Working Group. 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Memorandum 4 pp.
- Foote, A.D., R.W. Osborne, and A.R. Hoelzel. 2004. Whalecall response to masking boat noise. Nature 428:910.
- Fukuyama, A.K., Gillingham, G., and Hartwell, S.I. 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Benthic Infaunal Communities. Alaska Marine Science Symposium, Anchorage Alaska. January 2012.
- Geraci, J.R., and St. Aubin, D.J. (eds.), 1990. Sea Mammals and Oil: Confronting the Risks, Academic Press, San Diego, CA, 282 pp.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 79

- Goetz, K.T., P.W. Robinson, R.C. Hobbs, K.L. Laidre, L.A. Huckstadt, and K.E.W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.
- Hansen, D.J., and J.D. Hubbard. 1999. Distribution of Cook Inlet beluga whales (*Delphinapterus leucas*) in winter. Final Rep. OCS Study. MMS 99-0024. U.S. Department of the Interior, Minerals Management Service. Alaska OCS Region, Anchorage, AK.
- Harris, R.E., G.W. Miller and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Mar. Mamm. Sci. 17(4):795-812.
- Hart Crowser, Inc./Pentec Environmental and Illingworth & Rodkin, Inc. 2009. Acoustic monitoring and in-situ exposures of juvenile coho salmon to pile driving noise at the Port of Anchorage Marine Terminal Redevelopment Project, Knik Arm, Anchorage, Alaska. Prepared for URS Corporation, ICRC, and Maritime Administration. Oct 21, 2009.
- Hartin, K.G., C.M. Reiser, D.S. Ireland, R. Rodrigues, D.M.S. Dickson, J. Beland, and M. Bourdon. 2013. Chukchi Sea vessel-based monitoring program. (Chapter 3) In: Funk, D.W., C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2013. Joint Monitoring Program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Report P1213-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for
- Hastings, M.C. and A.N. Popper. 2005. Effects of sound on fish. California Department of Transportation (Caltrans). Contract 43A0139 Task Order 1.
- Hobbs, R.C. and J.M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fishery Bulletin 108:251-267.
- Hobbs, R. C., K. E. W. Shelden, D. J. Rugh, and S. A. Norman. 2008. 2008 status review and extinction risk assessment of Cook Inlet belugas. AFSC Processed Report 2008-02, 116 p. Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service. 7600 Sand Point Way NE, Seattle, WA 98115.
- Hobbs, R.C., K.L. Laidre, D.J. Vos, B.A. Mahoney, and M. Eagleton. 2005. Movements and Area Use of Belugas, *Delphinapterus leucas*, in a Subarctic Alaskan Estuary. Arctic 58(4), 331-340.
- Illingworth & Rodkin, Inc. (I&R). 2007. Compendium of pile driving sound data. Report prepared for California Department of Transportation (Caltrans). Illingworth & Rodkin, Inc., Petaluma, CA.
- Illingworth & Rodkin, Inc. (I&R). 2013 Cook Inlet Exploratory Drilling Program – Underwater Sound Source Verification Assessment. Report prepared for BlueCrest Energy, Inc. Illingworth & Rodkin, Inc., Petaluma, CA. 20 pp.
- Johnson, C.S., M.W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustical Society of America 85:2651–54.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 80

- Johnston, D.W. 2002. The effect of acoustic harassment devices on harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada. *Biological Conservation* 108:113-118.
- Jones, B, D. Holen, and D. S. Koster. 2015. The Harvest and Use of Wild Resources in Tyonek, Alaska, 2013. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 404. Anchorage.
- Jones, B and M.L. Kostick. 2016. The Harvest and Use of Wild Resources in Nikiski, Seldovia, Nanwalek, and Port Graham, Alaska, 2014. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 420. Anchorage.
- Kastak, D., B.L. Southall, R.J. Schusterman and C. Reichmuth Kastak. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. *J. Acoust. Soc. Am.* 118(5):3154-3163.
- Kendall, L.S., K.Lomac-MacNair, G. Campbell, S. Wisdom, and N. Wolf. 2015. SAExploration 2015 Cook Inlet 3D Seismic Surveys Marine Mammal Monitoring and Mitigation Report. Prepared for National Marine Fisheries Service Permits and Conservation Division Office of Protected Resources 1315 East-West Highway Silver Spring, MD 20910, National Marine Fisheries Service, Alaska Region Protected Resources Division 222 W. 7th Ave, #43, Anchorage, AK 99513, and U.S. Fish and Wildlife Service 1011 East Tudor Rd. Anchorage, AK 99503. Prepared by Fairweather Science 301 Calista Court, Anchorage, AK 99518. 12.18.2015.
- Ketten, D.R. 1994. Functional analysis of whale ears: adaptations for underwater hearing. *IEEE Proc. Underwater Acoustics* 1:264-270.
- Kryter, K.D. 1985. The effects of noise on man, 2nd ed. Academic Press, Orlando, FL. 688 p.
- Laidre, K. L., K. E. W. Sheldon, D. J. Rugh, and B. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. *Mar. Fish. Rev.* 62(3):27-36.
- LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices. http://www.nmfs.noaa.gov/pr/permits/incidental/oilgas/ion_shell_2012iha_jmp_final_comprpt.pdf
- Ljungblad, D.K., B. Würsig, S.L. Swartz, and J.M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic* 41(3):183-194.
- Lomac-MacNair, K., M.A. Smultea and G. Campbell. 2014. Draft NMFS 90-Day Report for Marine Mammal Monitoring and Mitigation during Apache's Cook Inlet 2014 Seismic Survey, 2 April – 27 June 2014. Prepared for Apache Alaska Corporation, 510 L Street #310, Anchorage AK 99501. Prepared by Smultea Environmental Sciences (SES), P.O. Box 256, Preston, WA 98050.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 81

- Lomac-MacNair, K.S., L.S. Kendall, and S. Wisdom. 2013. Marine Mammal Monitoring and Mitigation, 90-Day Report, May 6- September 30, 2012, Alaska Apache Corporation 3D Seismic Program, Cook Inlet, Alaska. Prepared by SAExploration 8240 Sandlewood Pl. Suite 102 Anchorage, AK and Fairweather Science 9525 King Street, Anchorage, AK. Prepared for Apache Alaska Corporation and National Marine Fisheries Service. 87 p.
- Lucke, K., U. Siebert, P.A. Lepper, and M.-A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America* 125(6):4060-4070.
- M. M. Muto, V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-355, 366 p. doi:10.7289/V5/TM-AFSC-355.
http://www.nmfs.noaa.gov/pr/sars/pdf/ak_2016_final_sars_june.pdf
- MacGillivray, A., G. Warner, R. Racca, and C. O'Neill. 2011. Tappan Zee Bridge construction hydroacoustic noise modeling: Final report. Report by JASCO Applied Sciences for AECOM. 63 pp.
- Mahoney, B.A. and K.E.W. Shelden. 2000. Harvest history of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. *Marine Fisheries Review* 62(3), 124-133.
- Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior (BBN Report No. 5366; NTIS PB86-174174). Report from Bolt Beranek and Newman Inc. for U.S. Minerals Management Service, Anchorage, AK.
- Markowitz, T.M. and T.L. McGuire, eds. 2007. Temporal-spatial distribution, movements and behavior of beluga whales near the Port of Anchorage, Alaska. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, for Integrated Concepts and Research Corporation and the U.S. Department of Transportation Maritime Administration.
- McCaughey, R. D., Jenner, M-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. *Australian Petroleum Production and Exploration Association Journal*, 38, 692-707.
- McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. *Journal of the Acoustical Society of America* 98:712-721.
- Melcón ML, A.J. Cummins, S.M. Kerosky, L.K. Roche, S.M. Wiggins, J.A. Hildebrand. 2012. Blue Whales Respond to Anthropogenic Noise. *PLoS ONE* 7(2): e32681.
<https://doi.org/10.1371/journal.pone.0032681>

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 82

- Miller, G. W., V. D. Moulton, R. A. Davis, M. Holst, P. Millman, A. MacGillivray and D. Hannay. 2005. Monitoring seismic effects on marine mammals – southeastern Beaufort Sea, 2001–2002. In S. L. Armsworthy, P. J. Cranford, and K. Lee (Editors), Offshore Oil and gas environmental effects monitoring: approaches and technologies, p. 511–542. Battelle Press, Columbus, Ohio.
- Montgomery, R.A., J.M. Ver Hoef, and P.L. Boveng. 2007. Spatial modeling of haul-out site use by harbor seals in Cook Inlet, Alaska. *Mar. Ecol. Progr. Ser.* 341:257-264.
- Morton, A.B. and H. K. Symonds. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. *Jour. of. Mar. Sci.* 59:71-80.
- Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in northern Cook Inlet, Alaska. *Alaska Fisheries Research Bulletin* 4: 154-177.
- Moulton, V.D. and G.W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. p. 29-40 in K. Lee, H. Bain and G.V. Hurley, eds. 2005. *Acoustic Monitoring and Marine Mammal Surveys in the Gully and Outer Scotian Shelf before and during Active Seismic Programs.* Environmental Studies Research Funds Report. No. 151. 154 p.
- MTS. 2016. Benthic infaunal sampling and analysis of samples collected for AK LNG dredge material sampling characterization project in Nikiski, AK 2016. Attachment 16 Benthic testing report by Marine Taxonomic Services, in CH2M. Nikiski Capital Dredge Material Characterization Report. AKLNG-4040-MAR-RTA-DOC-00088. Report prepared for Alaska Gasline Development Corporation, Anchorage, AK. 239 pp.
- Mulherin, N.D., W.B. Tucker III, O.P. Smith, and W.J. Lee. 2001. *Marine Ice Atlas for Cook Inlet, Alaska.*
- Nakken, O. 1992. Scientific basis for management of fish resources with regard to seismic exploration. Fisheries and Offshore Petroleum Exploitation 2nd International Bergen, Norway, 6-8 April 1992.
- NMFS. 2005. Assessment of acoustic exposures on marine mammals in conjunction with USS Shoup active sonar transmissions in Haro Strait, Washington, 5 May 2003 (NMFS Office of Protected Resources report).
- NMFS. 2008. Conservation Plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). NOAA, NMFS, Juneau, AK.
- NMFS. 2016a. Recovery Plan for the Cook Inlet Beluga Whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK. https://alaskafisheries.noaa.gov/sites/default/files/cib_recovery_plan_final.pdf.
- NMFS. 2016b. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p. http://www.nmfs.noaa.gov/pr/acoustics/Acoustic%20Guidance%20Files/opr-55_acoustic_guidance_tech_memo.pdf.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 83

- National Research Council (NRC). 2005. Marine Mammal Populations and Noise: Determining When Noise Causes Biologically Significant Effects. National Academies Press.
- Nedwell, J.R, Langworthy, J., Howell, D. 2003. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise. Subacoustech Report No. 544R0424 commissioned by COWRIE.
- Nemeth, M. J., C. C. Kaplan, A. P. Ramos, G. D. Wade, D. M. Savarese, and C. D. Lyons. 2007. Baseline studies of marine fish and mammals in Upper Cook Inlet, April through October 2006. Final report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for DRven Corporation, Anchorage, Alaska.
- O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost, and A.E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. *Molecular Ecology* 6: 955-970.
- Olsen, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo survey vessel. *ICES Journal of Marine Science* 18: 21 pp.
- Olsen, K., Angell, J., Pettersen, F., and A. Lovik. 1983. Observed fish reactions to a surveying vessel with special reference to herring, cod, capelin, and polar cod. *FAO Fisheries Report* 300: 131-138.
- Ona, E. 1988. Observations of cod reaction to trawling noise. *ICES FAST WG-meeting*, Oostende, 20-22.
- Ona, E. and O.R. Godo. 1990. Fish reaction to trawling noise; the significance for trawl sampling. *Rapp. O-v Reun. Coast. Int. Explor. Mer.* 189:159-166.
- Ona, E. and R. Toresen. 1988. Reaction of herring to trawl noise. *ICES. CM* 1988/B-36:1-8.
- Owl Ridge NRC. 2014. Cosmopolitan State 2013 Drilling Program Marine Mammal Monitoring and Mitigation 90-day Report. Prepared for BlueCrest Alaska Operating LLC. 74 pp.
- Pentec. 2005. Marine Fish and Benthos Studies in Knik Arm, Anchorage, Alaska. Prepared for Knik Arm Bridge and Toll Authority and HDR Alaska, Inc. Report 12214-10/12214-12. Prepared by Pentec Environmental, Edmonds, Washington.
- Polacheck, T. and L. Thorpe. 1990. The swimming direction of harbor porpoise in relationship to a survey vessel. *Report. Int. Whal. Comm.* 40:463-470.
- Popper, A., A. Hawkins, R. Fay, D. Mann, S. Bartol, T. Carlson, S. Coombs, W. Ellison, R. Gentry, M. Halvorsen, S. Lokkeborg, P. Rogers, B. Southall, D. Zeddies, and W. Tavolga. 2014. Sound exposure guidelines for fishes and sea turtles: A technical report prepared by ANSI-Accredited Standards Committee. *ASA S3/SC1.4 TR-2014* 88pp.
- Popper, A.N. and M.C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* 75:455-489.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 84

- Rappeport, M.L. 1982. An analysis of oceanographic and meteorological conditions for central lower Cook Inlet, Alaska. U.S. Geological Survey Open-File Report 82-128.
- Reiser, C.M., B. Haley, J. Beland, D.M. Savarese, D.S. Ireland, and D.W. Funk. 2009. Evidence for short-range movements by phocid species in reaction to marine seismic surveys in the Alaskan Chukchi and Beaufort Seas. Poster presented at: 18th Biennial Conference on the Biology of Marine Mammals, 12–16 October 2009, Quebec City, Canada.
- Richardson, W.J. and C.I. Malme. 1993. Man-made noise and behavioral responses. Pp. 631-700 In J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.
- Richardson, W.J., B. Wursig, and C.R. Greene. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79:1117-1128.
- Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press, Inc. 576 pp.
- Richardson, W.J., R.S. Wells, and B. Wursig. 1985. Disturbance responses of Bowheads, 1980-1984. p. 255-306 in: W.J. Richardson, editor. Behavior, disturbance responses, and distribution of bowhead whales, *Balaena mysticetus* in the Eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034 USDOI, Minerals Management Services, Alaska OCS Region, Anchorage, AK.
- Ridgway, S. H., D.A. Carder, T. Kamolnick, R.R. Smith, C.E. Schlundt, and W.R. Elsberry. 2001. Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*Delphinapterus leucas*) (*Odontoceti, Cetacea*). Journal of Experimental Biology 204:3829-3841.
- Robards, M.D., J.F. Piatt, A.B. Kettle and A.A. Abookire. 1999. Temporal and geographic variation in fish communities of lower Cook Inlet, Alaska. Fishery Bulletin 97:962–977.
- Roni, P. and L. Weitkamp. 1996. Environmental Monitoring of the Manchester Naval Fuel Pier Replacement, Puget Sound, Washington, 1991-1994. Prepared for Department of the Navy, Naval Facilities Engineering Command, Western Division; and Coastal Zone and Estuarine Studies Division, NMFS, NOAA, Seattle, WA.
- Ruggerone, G., S. Goodman, and R. Miner. 2008. Behavioral response and survival of juvenile coho salmon exposed to pile driving sounds. Prepared for the Port of Seattle, Seattle, WA.
- Rugh, D. J., B. A. Mahoney, and B. K. Smith. 2004. Aerial surveys of beluga whales in Cook Inlet, Alaska, between June 2001 and June 2002. U.S. Department of Commerce. NOAA Tech. Memo. NMFS-AFSC-145.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 85

- Rugh, D.J., K.E.W. Shelden, C.L. Sims, B.A. Mahoney, B.K. Smith, L.K. (Litzky) Hoberecht, and R.C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. NOAA Technical Memorandum NMFS-AFSC-149. 71 pp.
- Rugh D. J., K.E.W. Shelden, R. C. Hobbs. 2010. Range contraction in a beluga whale population. *Endangered Species Research* 12:69-75.
- Saupe, S., J. Gendron, and D. Dasher. 2005. The Condition of Southcentral Alaska's Bays and Estuaries. A Statistical Summary for the National Coastal Assessment Program, Alaska Department of Environmental Conservation, March 15, 2006.
- Scheifele, P.M., S. Andrews, R.A. Cooper, M. Darre, F.E. Musick, and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal of the Acoustical Society of America*, 117, 1486-1492.
- Scientific Fishery Systems, Inc. (SFS). 2009. 2008 underwater noise survey during construction pile driving, Port of Anchorage Marine Terminal Development Project, in support of Alaska Native Technologies, LLC. Prepared for U.S. Department of Transportation Maritime Administration, Port of Anchorage, and Integrated Concepts and Research Corporation.
- Shelden, K.E.W., C.L. Sims, L. Vate Brattström, K.T. Goetz, and R.C. Hobbs. 2015. Aerial surveys of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2014. AFSC Processed Rep. 2015-03, 55 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.
- Shelden, K.E.W., D.J. Rugh, B.A. Mahoney, and M.E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: implications for a depleted population. *Marine Mammal Science* 19:529-544.
- Shelden, K.E.W., D.J. Rugh, K.T. Goetz, C.L. Sims, L. Vate Brattström, J.A. Mocklin, B.A. Mahoney, B.K. Smith, and R.C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-263, 122 p. <https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-263.pdf>
- Shelden, K.E.W., R.C. Hobbs, C.L. Sims, L. Vate Brattström, J.A. Mocklin, C. Boyd, and B.A. Mahoney, 2017. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016.
- Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.K. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. *Special Issue of Aquatic Mammals*, 33(4): 412-522.
- Stanek, R. T. 1994. The subsistence use of beluga whale in Cook Inlet by Alaska Natives. 1993. Draft Final Report for year two, subsistence study and monitoring system No.50ABNF200055. Technical Paper No. 232. ADF&G, Juneau, Alaska. 23-pp.
- Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. *J. Cetac. Res. Manage.* 8(3):255-263.

ALASKA LNG	Petition for ITRs for Alaska LNG Construction Activities in Cook Inlet, Alaska	AKLNG-6010-REG-GRD-DOC-00001
		Revision: 3
		February 20, 2018
	Public	Page 86

- Todd, S., P. Stevick, J. Lien, F. Marques, and D. Ketten. 1996. Behavioral effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). *Can. J. Zool.* 74:1661-1672.
- URS. 2007. Port of Anchorage Marine Terminal Development Project underwater noise survey test pile driving program, Anchorage, Alaska. Final underwater noise report. Prepared for Integrated Concepts and Research Corp. Infrastructure Support Services.
- U.S. Army Corps of Engineers (USACE). 2013. Maintenance Dredging, Cook Inlet Navigation Channel, Alaska. Environmental Assessment and Finding of No Significant Impact. Alaska District. 112 pp.
- U.S. Environmental Protection Agency (USEPA). 2002. Environmental Assessment for the New Source NPDES Forest Oil Redoubt Shoal Unit Production Oil and Gas Development Project. January 15, 2002. Prepared by Science Applications International Corporations, Bothell, WA for the U.S. Environmental Protection Agency, Region 10, Seattle, WA. 292 p.
- USFWS. 2004. Biological Opinion: Edmonds Crossing Ferry Terminal, USFWS Log # 1-3-03-F-1499. Prepared by U.S. Fish and Wildlife Service for the Federal Highway Administration, August 30, 2004.
- U.S. Geological Survey (USGS). 1999. Water-quality assessment of the Cook Inlet Basin, Alaska, - Environmental Setting. Water Resources Investigations Report 99-4025 National Water Quality Assessment Program. 76 pp.
- Wartzok, D. and D.R. Ketten. 1999. Marine mammal sensory systems. Pages 117-148 in J.E. Reynolds III and S.A. Rommel (eds), *Biology of Marine Mammals*. Washington D.C.: Smithsonian Institution Press.
- Watkins, W. A. 1986. Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science* 2: 251–262.
- Weilgart, L. S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. *Can. J. Zool.*, 85, 1091-1116.
- White, M.J., J. Norris, D.L. Jungblad, K. Baron, and G. Di Sciara. 1978. Auditory thresholds of two beluga whales (*Delphinapterus leucas*). HSWRI Technical Report 78-109. Prepared for Naval Ocean Systems Center, San Diego.
- Wolfe, R. J., C. L. Scott, W. E. Simeone, C. J. Utermohle, and M. D. Pete. 2009. The “super-household” in Alaska Native subsistence economies. Final report to the National Science Foundation. ARC 0352611.