Alaska LNG™

DOCKET NO. CP17-___-000
MARINE MAMMAL PROTECTION ACT ASSESSMENT REPORT

USAI-P2-SRZZZ-00-000007-000

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1.0 ACTIVITIES THAT COULD AFFECT MARINE MAMMALS

The purpose of this report is to provide additional detail on potential impacts associated with construction and operation of the Alaska LNG Project (Project) on marine mammals. One of the effects of the Project would be the generation of underwater sound in the marine environment. The sound levels likely to be generated by some Project activities are predicted to exceed thresholds established by the National Marine Fisheries Service as levels that could potentially result in incidental harassment of marine mammals. Marine mammals are protected under the Marine Mammal Protection Act, and such incidental harassment is illegal under the statute and its implementing regulations unless incidental take authorizations are first obtained from NMFS or U.S. Fish and Wildlife Service. This report therefore focuses on the potential impacts of underwater sound on marine mammals and has been prepared in the same format as an application for an incidental harassment authorization from the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) in that it contains the information for the 14 components required by 50 Code of Federal Regulations (C.F.R.) 216.104 for such a request. This approach allows a more practical means of addressing potential Project impacts to marine mammals and provides a product easily converted to an actual application when necessary.

This report address both construction and operation of the Project. In discussions with NMFS regarding incidental take authorizations for the Project, I was decided that the authorization would be obtained as Letters of Authorization under Incidental Take Regulations (ITRs). A Draft Petition for Incidental Take Regulations for construction of the Alaska LNG Project in Cook Inlet, Alaska (Draft ITR Petition, AGDC 2017) has been submitted to NMFS. Estimates of potential marine mammal exposures are being refined in the petition based on additional project details and the new NMFS (2016) technical guidance on underwater acoustic thresholds and effects on marine mammals.

1.1 PROJECT DESCRIPTION

The Project includes a Liquefaction Facility on the Kenai Peninsula and Interdependent Project Facilities consisting of the Mainline, the Gas Treatment Plant (GTP), the Point Thomson Unit (PTU) Gas Transmission Line (PTTL), and the Prudhoe Bay Unit (PBU).

There are also five identifiable categories of facilities that (i) are outside the scope of the proposed Project, (ii) would be owned and operated by third parties, and (iii) are beyond the Federal Energy Regulatory Commission's (FERC) jurisdiction under the Natural Gas Act (NGA), but (iv) support or relate to the Project:

- Modifications/new facilities at the PTU (PTU Expansion project).
- Modifications/new facilities at the PBU (referred to as the PBU Major Gas Sales [MGS] project), including a new pipeline from GTP to the PBU to transfer GTP Byproduct back to the PBU.
- Relocation of the Kenai Spur Highway.
- Possible modifications to or construction of manufacturing facilities to fabricate Project components outside of Alaska.
- Third-party pipelines and associated infrastructure to transport natural gas from the gas interconnection points to markets within Alaska (Gas Interconnect Point Facilities).

Non-jurisdictional facilities are outside the scope of the proposed Project as they would be owned and operated by third parties. Therefore, effects to marine mammals from construction and operation on the Non-Jurisdictional Facilities are not assessed in this document, which is an assessment of effects as considered under the Marine Mammal Protection Act (MMPA). The non-jurisdictional facilities are described in Resource Report No. 1. The effects of construction and operation of these facilities are, however, considered in Resource Report No. 3, and the Biological Assessment in Appendix C of Resource Report No. 3.

During construction, heavy lift vessels (HLVs) would transport prefabricated modules through the Bering, Chukchi, and Beaufort seas to Prudhoe Bay, as well as through the Gulf of Alaska to Cook Inlet. Once constructed, the Project operation of Liquefied Natural Gas Carriers (LNGC) to deliver LNG to foreign markets would be required. LNGCs would likely transit through the Aleutian Islands, Gulf of Alaska, Shelikof Strait or Kennedy/Stevenson Entrances, and Cook Inlet to markets in Asia.

A more detailed description of the Project is provided in Resource Report No. 1 and a Project overview, including vessel and LNGC routes, is depicted in Figure 1. This report concerns only activities associated with the construction and operation of the Project that could have direct or indirect effects on marine mammals. These components are:

- Construction and operation of the Marine Terminal in Cook Inlet;
- Construction and operation of the Mainline across Cook Inlet, including modification and use of an existing dock on the west side of Cook Inlet (or construction of a new Mainline MOF);
- Modification and use of West Dock in Prudhoe Bay;
- Vessel traffic associated with construction and operation of the Project in Cook Inlet, Gulf of Alaska, Bering Sea, Chukchi Sea, and the Beaufort Sea.

These Project components are described in the following sections and are depicted in Figures 1 through 4.

1.1.1 Marine Terminal

The Marine Terminal would be constructed adjacent to the LNG Plant in Cook Inlet and would allow LNGCs to dock and load LNG. As shown in Figure 2, the proposed marine facilities would include:

- Product loading facilities (PLF), which would support the piping that delivers LNG from shore to LNGCs and include all of the equipment to dock LNGCs. No dredging would be required to construct or operate the PLF.
- A temporary material offloading facility (MOF), which would be a dock used during Project construction to enable direct deliveries of materials, equipment, and other cargo to minimize the transport of large and heavy loads over road infrastructure. Dredging would be required to operate the MOF during construction.

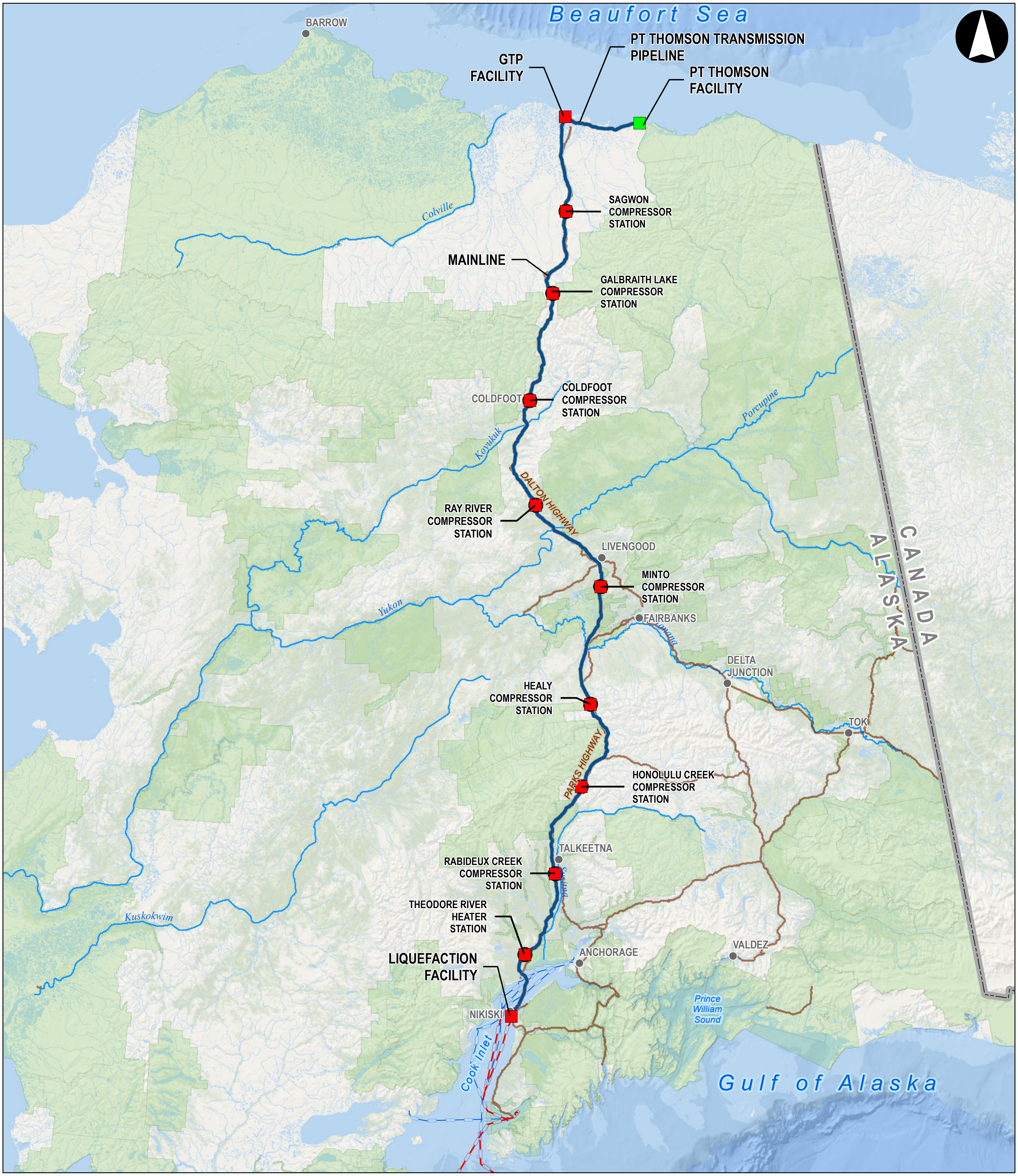
The PLF would be a permanent facility for the duration of the LNG export operations. The MOF consists of temporary facilities that would be removed during operations of the LNG Plant.

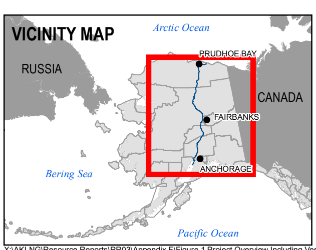
The schedule for Marine Terminal offshore construction activities is based on using ice-free working windows in Cook Inlet from approximately April 1 through October 31. Land required for construction and operation of the Marine Terminal is indicated in Table 1.

Table 1. Land Required for Construction and Operation of the Marine Terminal

Facility	Land Affected During Construction (acres)	Land Affected During Operation (acres)
Temporary MOF	11.32 [a]	0.00
Temporary MOF Dredging Area	50.70 [a]	0.00
Dredge Disposal Area	1,200 (600 acres/year during construction)	0.00
Shoreline Protection	1.54	0.00
PLF	18.67	18.67
Marine Terminal Total	**1,282.23**	**18.67**

[a] The temporary MOF footprint totals 28.3 acres; however, 16.93 acres are included within the MOF dredging footprint.





LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Proposed LNGC Route
- Vessel Route
- Major Highways
- Major Rivers
- State and Federal Conservation Lands

0 25 50 100 Miles

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PROJECT OVERVIEW INCLUDING VESSEL AND LNGC ROUTES

FIGURE 1

ALASKA LNG

X:\AKLNG\Resource Reports\RR03\Appendix F\Figure 1 Project Overview Including Vessel and LNGC Routes.mxd

LOCATION OF THE PROPOSED PROJECT MARINE TERMINAL

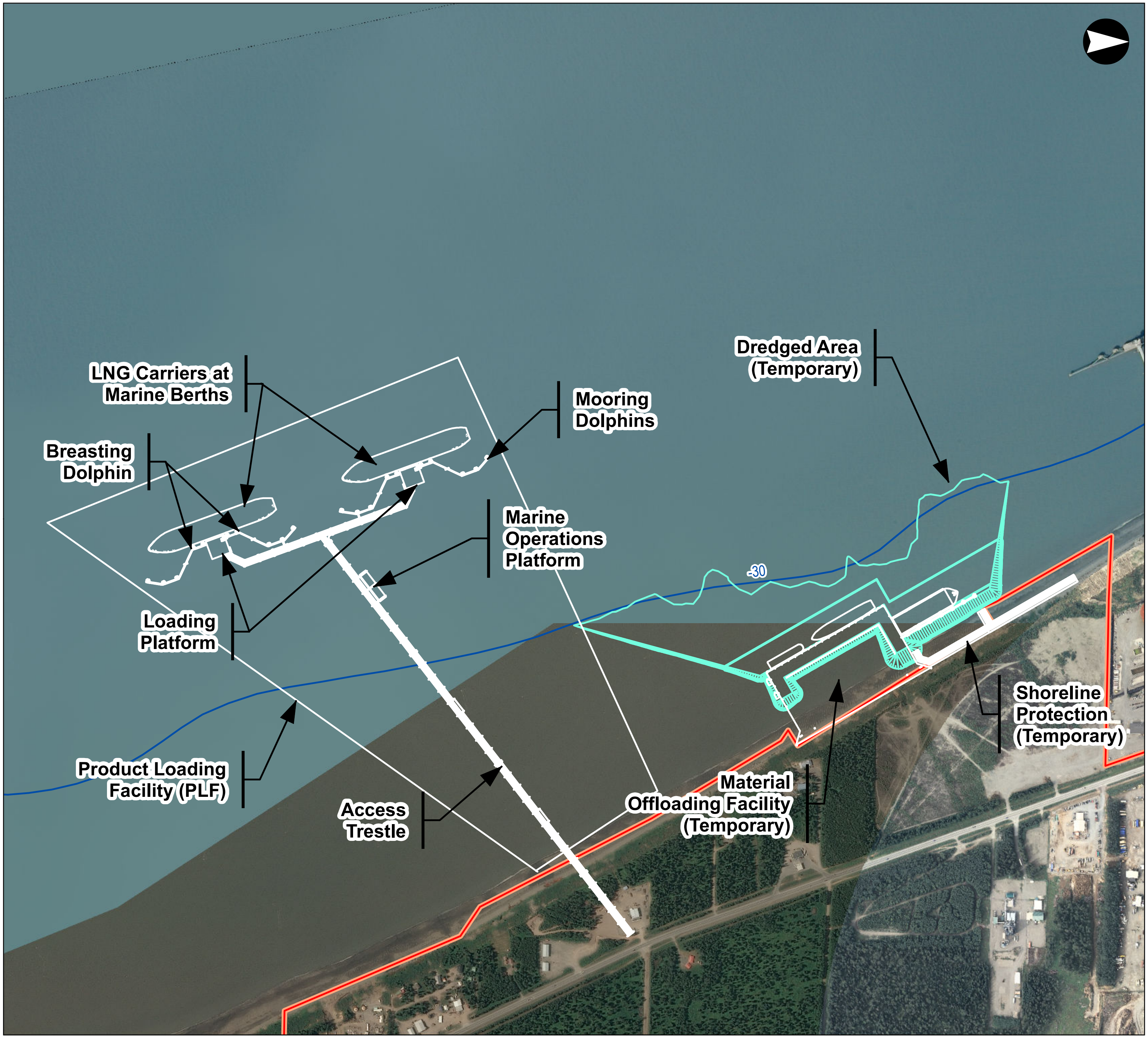
FIGURE 2

ALASKA LNG

LEGEND

- 30 foot Bathymetry Contour from Project Surveys
- LNG Marine Facility
- MOF Dredging Area
- Proposed Plant Boundary

0 250 500 1,000 Feet



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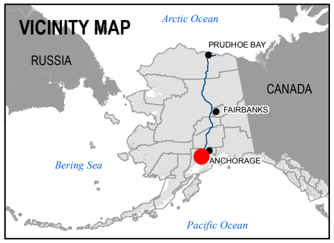
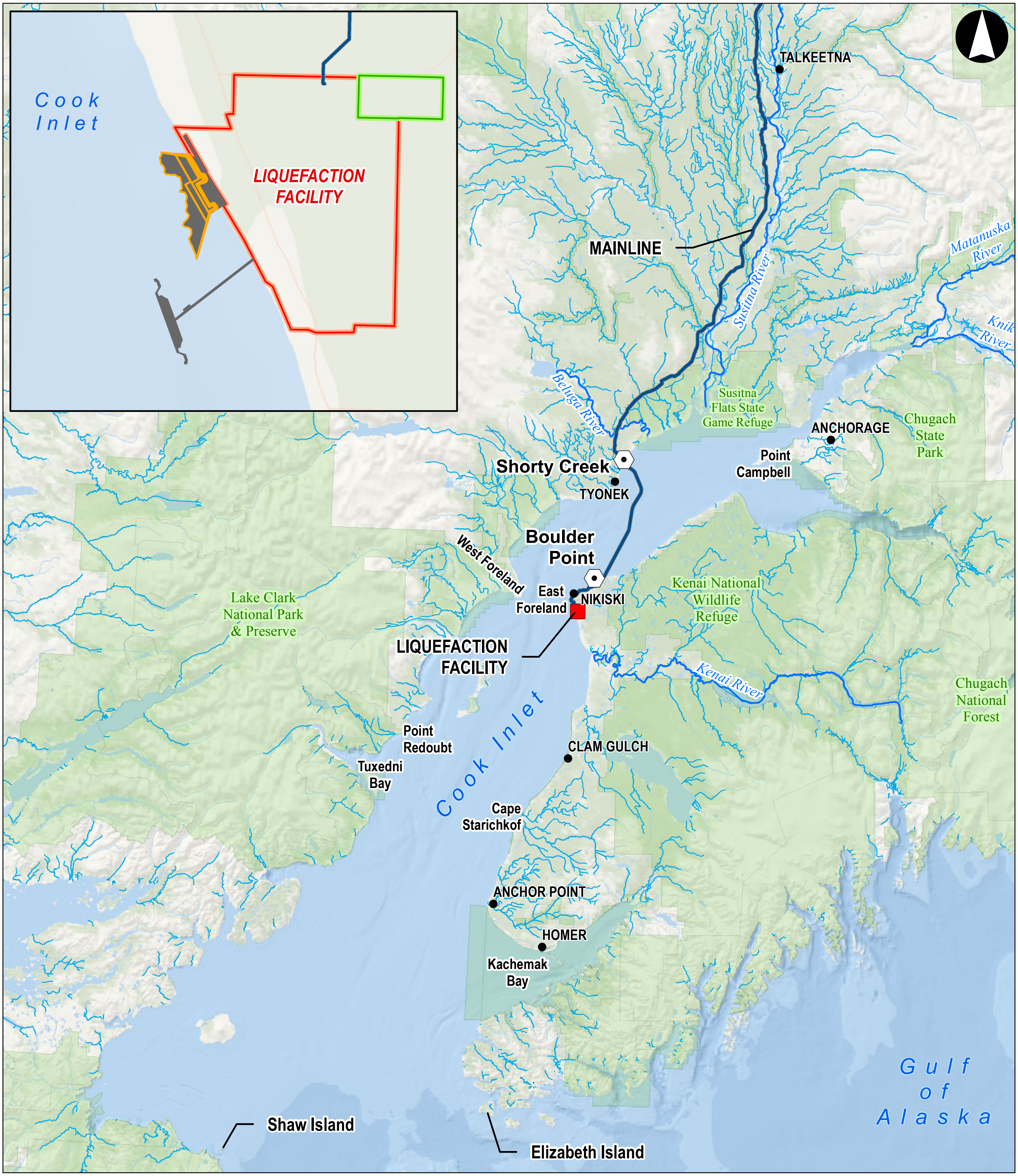
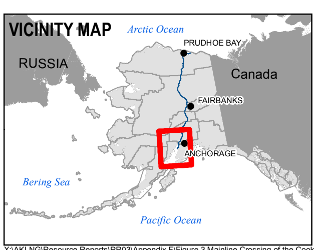
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix F\Figure 2 Location of the Proposed Project Marine Terminal.mxd





LEGEND

- Alaska Place Names
- Project Facility
- Crossing Point
- Alaska LNG Rev C2 Route
- Anadromous Waters
- Major Rivers
- Marine Facility

Liquefaction Facility
- LNG Operations Area
- LNG Construction Camp

- State and Federal Conservation Lands

0 10 20 40 Miles

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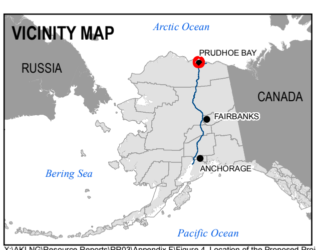
MAINLINE CROSSING OF THE COOK INLET

FIGURE 3

ALASKA LNG

X:\AKLNG\Resource Reports\RR03\Appendix F\Figure 3 Mainline Crossing of the Cook Inlet.mxd

VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix F\Figure 4 Location of the Proposed Project West Dock Modifications.mxd

LEGEND

Alaska LNG Rev C2 Route

PTTL

Existing Infrastructure

GTP Facility

Facility

Study Area

0 0.5 1 2 Miles

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LOCATION OF THE PROPOSED PROJECT WEST DOCK MODIFICATIONS

FIGURE 4

ALASKA LNG

1.1.1.1 Product Loading Facilities (PLF)

1.1.1.1.1 Use of the PLF

The purpose of the PLF would be to load LNGCs for export from Nikiski. Based on a nominal 176,000 cubic meters LNGC design vessel, approximately 21 vessel visits per month would be required to export the produced LNG. The LNGCs would range in size between 125,000 cubic meters (approximately 30 vessel visits per month) and 216,000 cubic meters (approximately 17 vessel visits per month).

1.1.1.1.2 Ballast and Cooling Water Discharges

LNGCs calling at the Marine Terminal would be carrying ballast water (sea water) upon arrival to Cook Inlet. The ballast water would have been exchanged in international waters according to regulatory requirements. As LNG would be loaded onto the LNGCs at the Marine Terminal, the LNGCs would release the ballast water, thereby replacing the sea water with LNG product as ballast to maintain stability of the LNGC during transit. Approximately 2.9 to 3.2 billion gallons of ballast water would be discharged per year from LNGCs during LNG loading operations at the Marine Terminal, with the range in annual discharge volume due to varying LNGC sizes and number of voyages which may call at the Marine Terminal. The water discharged would be approximately 0-25 degrees Fahrenheit warmer than ambient water temperature in Cook Inlet. Ballast water discharged in Cook Inlet would be treated according to United States regulations.

Approximately 1.6-2.4 billion gallons of sea water per year may be taken in and discharged by LNGCs as cooling water while at the Marine Terminal. The water would undergo minimal filtration upon intake and supports a non-contact heat exchange process to provide cool water needed for the LNGC integrated cooling systems for equipment onboard such as main engines and diesel generators. The range in intake/discharge volumes accounts for the varying LNGC sizes and estimates of the number of LNGC calls at the Marine Terminal. The water discharged could be approximately 5 degrees Fahrenheit warmer than ambient water temperature in Cook Inlet.

1.1.1.2 Material Offloading Facilities

Activities associated with construction and uses of the MOF are described below.

1.1.1.2.1 Description of the Temporary MOF

The temporary MOF would facilitate the marine import of bulk materials, equipment, and modules during construction. The MOF would be a temporary facility and would be removed approximately 10 years after completion of its construction.

The temporary MOF area would be approximately 1,050 feet by 525 feet with a deck elevation +32 feet mean lower low water (MLLW), which would provide sufficient space for cargo discharge operations, and up to three sealift seasons of module shipments. MOF construction would be land-based work. The MOF is designed to consist of a combi-wall of pilings and sheets backfilled with granular materials and tied back to a sheet pile anchor wall.

1.1.1.2.2 Dredging for the Temporary MOF

The approach and berths at the temporary MOF would need to be dredged to the depths of -30 feet and -32 feet MLLW, respectively, with an additional allowance of no more than -2 feet that may be required for overdredge. Several disposal and/or reuse options are under consideration. Given the total volume of dredging planned at the site and the potential for multi-year maintenance dredging, an offshore, unconfined aquatic disposal site would be the preferred option for disposal of the dredged material. The proposed dredge disposal area is located approximately 3-5 miles west of the dredge area in relatively deep water (-60 feet to -100 feet

MLLW), with strong northerly currents (over 6.5 knots peak flood and over 5.5 knots peak ebb), which are expected to disperse the dredge sediment, but not carry the material back towards shore. The deep water and strong currents are expected to disperse the material with no impact on water depth (navigation).

The dredged material is anticipated to be a heterogeneous mix of sandy silt and sand with hard packed clay. The estimated volume of material that would be dredged for the Marine Terminal totals approximately 800,000 cubic yards.

Additionally, 140,000 cubic yards (approximately) of maintenance dredging is expected to be necessary at the temporary MOF berths and approach during the later construction seasons.

Dredging at the temporary MOF during the first season of marine construction may be conducted with either an excavator or clamshell (both mechanical dredges). Dredging at the MOF during the second season of marine construction at Nikiski may be conducted with either a hydraulic (cutterhead) dredger or a mechanical dredger.

1.1.2 Mainline Construction Across Cook Inlet

The proposed Cook Inlet crossing route for the Mainline is an approximate 28-mile stretch between Shorty Creek near the Village of Beluga on the western shore of upper Cook Inlet to Boulder Point on the eastern side of the inlet. Figure 3 provides an overview of Cook Inlet Mainline crossing. Land requirements for construction and operation of the Mainline are provided in Table 2. These numbers do not represent expected impacts; they are based on right-of-way widths. The construction right encompasses an area 1.25 mile on either side of the centerline to include all areas where anchors may be set. The expected footprint of the 12 plus anchors within the 2.5-mile-wide construction ROW is expected to be less than 1 acre each time the anchors are picked up and moved. The number of times the anchors would be reset would be dictated by weather, current conditions, and the rate of pipelay progress; however, only a fraction of the required construction ROW would be impacted. At a nominal frequency of resetting anchors once per mile, up to 336 acres of seafloor would be impacted by anchor setting and retrieval. Additional seafloor would be affected by cable sweep as the barge is pulled forward with anchors in place.

Table 2.Land Requirements for Construction and Operation of the Mainline Cook Inlet Crossing

Facility	ROW Required During Construction (acres)	Land Affected During Operation (acres)
Construction	38,131.76 [1]	330.11

[1] Includes the width of anchoring the offshore pipelay barge, currently assuming a 2.5-mile-wide anchor spread (total). The majority of the construction ROW would not be disturbed during construction.

The pipeline crossing would be installed over two years, with the working window for construction in Cook Inlet being mid-April to mid-October. The expected pipelay vessel progress would be between approximately 2,000 and 5,000 feet per 24 hour day, depending on currents and weather. The shoreline crossings would be constructed in the first year and the main pipelay operation would occur the second year.

The pipe would be laid using a pipelay vessel, which moves by pulling on its anchors or through the assistance of its dedicated support vessels. Certain pipelay vessels may also have integral thrusters to provide propulsion. The specific vessel that would be used would be finalized during procurement of the installation contractor. Several anchor handling tugs (AHTs) would be used to reposition the anchors after pipe is welded and lowered over the back of the pipelay vessel.

Primary underwater sound sources would be from the AHTs during the anchor-handling, vessel power generation and thrusters from the pipelay vessel (if equipped).

1.1.2.1.1 Shoreline Crossings

The pipeline would be installed at the shoreline crossings on both sides of Cook Inlet using the open cut method. In Cook Inlet, the pipeline would be buried from the shoreline out to a water depth of between 35 to 45 feet, which represents a distance of 8,300 to 8,800 feet at the Shorty Creek crossing and 6,400 to 6,600 feet at the Boulder Point crossing location. Seaward of these locations, the pipeline would be laid on the seafloor. Construction methods would differ between the nearshore and offshore portions of these trenched sections.

The trench for each shoreline is expected to be constructed using amphibious or barge-based excavators to trench to a transition water depth where a dredge vessel can be employed. A backhoe dredge could also be required to work in the nearshore region. Following pipeline installation, the trench is expected to naturally backfill.

In the event the pipeline is required to be buried beyond water depths accessible by amphibious excavators, a trailing suction hopper dredger (TSHD) would be used in advance to provide the necessary trench for the pipeline. Alternative dredging or burial techniques, such as plowing, or jetting, will be evaluated once sufficient geotechnical information is collected and analyzed along the route. After installation of the nearshore pipelines, a jetsled or mechanical burial sled could be used to achieve post dredge burial depths.

1.1.2.1.2 Hydrostatic Testing

Seawater from the Cook Inlet would be used to hydrostatically test the integrity of the pipeline after welding. Water is pumped into the pipeline behind a fill plug, pressurized above intended operating pressures, and then discharged after the required test holding period. The necessity of additives (e.g. corrosion inhibitor, biocide) will be evaluated as well as freshwater alternatives. The hydrotest water discharge would be performed in compliance with regulatory requirements.

1.1.3 West Dock Modifications

The West Dock Causeway, which runs approximately 2.5 miles from the shoreline to the west end of Prudhoe Bay, is a solid fill granular material structure that was constructed in three segments between 1974 and 1981. Construction of the GTP at Prudhoe Bay would require barge delivery of modules to West Dock over four sealift seasons. Modifications of the existing West Dock facilities would be necessary to facilitate offloading a large number of barges within a short ice-free work window. Land requirements for the construction and operation of Project facilities at West Dock are identified in Table 3.

Table 3.Land Required for Construction and Operation of the West Dock Facilities

Facility	Land Affected During Construction (acres)	Land Affected During Operation (acres)
Dock Expansion	31.05	0.00[a]
Barge Bridge	2.58	0.00[a]
Berthing Basin	13.70	0.00
West Dock Modifications Total	**47.33**	**0.00**

Note:[a] Subject to commercial negotiations.

1.1.3.1 Dock Head 4

A new Dock Head (DH 4) with five or more berths would be built at the seawater treatment plant (STP). The West Dock DH 4 addition would include installing sheet piling and fill material behind the sheet piling, and installing mooring dolphins, to provide a sufficient surface for grounding the cargo barges. Most of the piles would be placed with an impact hammer during the winter. A barge bridge would be required to facilitate construction. The dock face would be approximately 1,000 feet wide and elevated approximately 8 feet. The five or more new berths would be dedicated to Project activities. The new dock would provide a working area of approximately 31 acres. The dock face would be approximately 1,000 feet wide and elevated approximately 8 feet. The five-new berths would be dedicated to activities. The new dock would provide a working area of approximately 31 acres.

1.1.3.2 Barge Bridge

An existing bridge within the West Dock causeway spans 650-foot channel/breach located between DH 2 and DH 3. The bridge limits the roadway to a single-lane, to light vehicle traffic at a width of 20 feet, and to an approximate load limit of 100 tons. A bridge with capacity to support the modules would be required for a successful sealift. Therefore, a temporary barge bridge, consisting of two barges ballasted to the sea floor, would be used to span the gap. The barges would be placed at the beginning of the open-water season prior to each sealift.

The barge bridge will provide up to three areas for fish passage, if required during the proposed time of use (e.g. between the barges and between each barge and the adjacent bulkhead). Pre-work would be performed a year before the first sealift to prepare the seafloor and install a minimum of four breasting-dolphins for the barge bridge support. The seabed surface would be prepared each year prior to the sealift using fill, and placement of rock gabions. Grading of the seafloor is expected to be done in winter through the ice using excavators to fill or grade the seafloor.

1.1.3.3 Use of Dock Head 4

Major components of the GTP would be built as modules offsite and delivered to Dock Head 4 in a series of sealifts. Four consecutive summer sealift seasons and corresponding construction periods are planned. The expected frequencies of large vessel traffic into Dock Head 4 for construction of GTP are indicated in Section 2.7.1.4.

Due to the size of the modules required for the GTP, large oceangoing vessels would be used. All cargo barges would be grounded for the modules offloaded at DH4. The grounding pad for the barges would be prepared in advance of each sealift. In total, construction for the GTP facility would last 8 years.

1.1.4 Vessel Traffic

Marine vessel traffic associated with the Project would occur during construction and operation. In addition to the mobilization of vessels for marine construction, vessels would be required to bring in facility modules, pipe, equipment, and supplies. The primary ports that would be used are the Port of Anchorage, the temporary MOF in Cook Inlet, Seward, and West Dock in Prudhoe Bay. During facilities operations, LNGCs would deliver natural gas to foreign markets. Vessel routes are unknown at this time; however, likely corridors are indicated in Figures 1, 6, and 7.

1.1.4.1 Vessel Traffic During Construction

The anticipated numbers and types of vessels needed to support construction are listed in Table 4.

Table 4. Typical Vessel Types that would be used during Project Construction

Facility	Activity	Vessel	Anticipated Number of Vessels
Marine Construction	Dredging	Hydraulic Dredge	1
		Dredging Barge (barge-mounted crane, clamshell)	1
		Deck Barge/Material Barges	TBD
		Scow/Hopper Barges	TBD
		Tug Boats	TBD
		Work/Crew Boats	TBD
		Survey Vessel	1
	Marine Construction Spreads	Derrick Barge	TBD
		Material Barge	TBD
		Tug	TBD
		Work/Crew Boats	TBD
	Materials Transport	Geared Heavy Lift Vessel	TBD
		Heavy Transport Vessel	TBD
		Ocean Tug and Barge	TBD
Pipeline	Pipeline Shipments	Ocean Tug and Barges	TBD
	Marine Construction Spreads	Pipelay Vessel	1
		Pull Barge	1
		Anchor Handling Tugs	3
		Supply/Pipe-Haul Vessels	2
		Work/Crew Boats	1
		Survey Vessel	1
		Nearshore Trenching/Backfilling Spreads	TBD
	Materials Transport	Ocean Tug and Barge [1]	61

[1] Each is one ocean going tug and one barge; they would be supported by 2 primary and 4 secondary assist tugs.

1.1.4.1.1 Construction Vessel Traffic at the Temporary MOF

There would be approximately 60 module shipments made directly to the temporary MOF from fabrication yards during the three years of active Liquefaction Facility construction. A Pioneer MOF would support construction prior to completion of the MOF and during peak construction periods. The Pioneer MOF would make use of an existing dock facility and would be expected to receive approximately 20 shipments of small modules for construction of the Marine Terminal during the third year of construction. It is anticipated that approximately 10 barges would be circulating from the ports of Anchorage and Seward to the Project's onsite MOF on a weekly basis for three years.

Modules would be fabricated outside of Alaska and transported directly to the Nikiski Liquefaction Facility site. Modules weighing up to 770 U.S. tons would be transported by lift-on/lift-off (Lo/Lo) self-propelled Geared Heavy Lift Ships. Modules weighing more than 770 U.S. tons would be loaded and discharged by roll-on/roll-off (Ro/Ro) methods using a self-propelled modular transporter. Typical vessels for dredging, marine construction spreads, material transport, and heavy lift are summarized in Table 4.

1.1.4.1.2 Construction Vessel Traffic for Cook Inlet Crossing Pipelay

Platform Supply Vessels (PSVs) would be used to support the trenching and pipelay activities during construction of the Mainline crossing of Cook Inlet. Typical vessels for dredging, marine construction spreads, material transport, and heavy lift are summarized in Table 4. Approximately 100 trips between the pipelay/trenching spread and a shore base (assumed to be Port Mackenzie) would be required to supply and support these activities over the course of the construction window. Barge-based vessels that would be used for logistics or pipelay have a typical transit speed of 5 knots while towed. PSV or Anchor Handling Tug Supply Vessels (AHTSs) transit speed is generally in the range of 10-12 knots. Ship shape pipelay (HLV) vessels transit at speeds in the in a range of 8-15 knots.

1.1.4.1.3 Construction Vessel Traffic Associated with Pipe Delivery

The pipe for the Mainline and PTTL would be shipped to the Port of Anchorage or Seward from outside of Alaska. The pipe would be delivered to Anchorage or Seward in 15,000 to 18,000-ton ships over several construction seasons. An estimated 47 vessel trips would transport the pipe over a 34-month shipping schedule (approximately 0.7 trips per month or one every 22 days) in the 2.5 years prior to the start of pipeline construction.

The ships would be Handymax class vessels or similar and would transit at speeds of 10 to 14 knots in the open ocean. Vessels transiting within Cook Inlet or Resurrection Bay (to or from Seward) would transit at about 10 to 14 knots. From Anchorage or Seward, pipe would be distributed to onshore pipe storage yards by rail or by barge to multiple locations, including to the Mainline MOF on the west side of Cook Inlet.

1.1.4.1.4 Construction Vessel Traffic at West Dock

Approximately 51 modules would be delivered to the proposed Dock Head 4 (DH 4) at West Dock during GTP construction as part of four planned sea lifts (117 total vessel trips). The number of barge and tugs that would be required for each sealift are indicated in Table 5. Sea lifts would be delivered at DH4 each of the four years during the ice-free period.

Table 5. Typical Vessel Types that would be used during GTP Construction

Sea Lift Year	No. Barges 400x105 & 400x130	Ocean going tugs (120 ton)	Primary Assist Tugs (42.5 ton)	Secondary Assist Tugs (15 ton)
Sea Lift 1	12	12	2	4
Sea Lift 2	12	12	2	4
Sea Lift 3	10	10	2	4
Sea Lift 4	9	9	2	4

1.1.4.2 Vessel Traffic During Operations

Operational traffic would include LNGCs traveling to and from the Liquefaction Facility to foreign markets. Tanker sizes have not been determined at this time, but are expected to range in length from 306.2 to 344.5 yards with capacities of between 125,000 and 216,000 cubic meters. Depending on the tanker size, an LNGC would arrive at the Marine Terminal 17 to 30 times per month. Additional vessels to be used during operations would include a pilot boat and one or more Azimuth Stern Drive (ASD) tugs to support carrier approach and docking (Table 6). LNGCs would transit open ocean waters at speeds of about 19 knots or less. In Cook Inlet, the LNGCs would transit at a speed to maintain steerage in the strong currents and have the ability to avoid marine mammals.

Table 6. Typical Vessel Types that would be used during Project Operation

Facility	Activity	Vessel
Marine Terminal	LNG Operations	Liquefied Natural Gas Carrier
		ASD Tug
		Southwest Alaska Pilots Association Pilot Boat

2.0 DATES AND DURATION OF PROPOSED ACTIVITY AND SPECIFIC GEOGRAPHICAL REGION

Construction of the Project is proposed to begin in 2019 and would likely require 5 to 7 years to complete. The dates, duration, and specific location of the three project activities most likely to have MMPA concerns are addressed in subsequent sections and described in more detail in Resource Report No 1.

2.1 MARINE TERMINAL CONSTRUCTION

While site access and preparation activities would begin in 2019, actual construction of the PLF and MOF would begin in 2020 and be completed in 2021. The construction of the PLF trestle would begin in 2022 and finish in 2024. Berth construction and module offload would occur in 2022-2024. The location of the proposed Marine Terminal is found in Figure 2.

2.2 MAINLINE OFFSHORE CONSTRUCTION

Pipeline construction across Cook Inlet would occur during the open water seasons of 2022 and 2023. The location of the planned route across the inlet is found in Figure 3.

2.3 WEST DOCK MODIFICATIONS

Construction of infrastructure at West Dock is proposed to begin in 2019 and be completed by 2023. This would include camps, construction of granular pads, and access roads. Following site preparation and infrastructure activities, sealift modules would be delivered. Because of the limited seasonal window (approximately 45 days) when Prudhoe Bay is ice-free, it is expected to take four seasons (2020-2024) to complete the barge trips necessary to deliver the modules and materials. The specific location of the West Dock modification activities is found in Figure 4.

3.0 THE SPECIES AND NUMBERS OF MARINE MAMMALS LIKELY TO BE FOUND WITHIN THE ACTIVITY AREA

With the exception of some associated vessel traffic, marine water construction activities would all occur in either Cook Inlet or Prudhoe Bay. Construction in Cook Inlet would include construction of the Marine Terminal near Nikiski, construction of a Mainline MOF on the western shore of Cook Inlet, and installation of the offshore portion of the Mainline. Construction activities at these sites would include pile driving, pipelay, dredging, and shipment of materials via barges and other vessels to both MOFs.

Construction in Prudhoe Bay would primarily include modifications to the existing West Dock facility. To receive the GTP plant modules, the West Dock facility would have to be modified, which could include driving of additional support piles and dolphins. Shipping of the plant modules would require use of ocean tugs and barges to transport the modules from manufacturers outside Alaska to West Dock. The barges would transit through Alaskan waters of the North Pacific, Bering Sea, Chukchi Sea, and Beaufort Sea

LNG shipping to Asian markets during the operational phase would involve transit through Cook Inlet, the North Pacific, and the Bering Sea (when following the Great Circle Route).

Each of the marine waterbodies within which construction or operational activities would occur is seasonally inhabited by a distinct suite of marine mammal species. Each is addressed separately in the following sections.

3.1 COOK INLET

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 move to mid and/or lower Cook Inlet during winter as the upper inlet largely freezes over. Other species in the lower inlet include humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostra*), gray whales (*Eschrichtius robustus*), killer whales (*Orcinus orca*), Dall's porpoise (*Phocoenoides dalli*), Steller sea lions (*Eumetopia jubatus*), and northern sea otters (*Enhydra lutris kenyoni*). 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, none of the latter six species are 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, but could be encountered during vessel transits through lower Cook Inlet. The status and estimated stock size of marine mammals found in Cook Inlet are shown in Table 7.

Table 7. Cetaceans and Pinnipeds in the Cook Inlet Project Area

Species	Stock Estimate[1]	Stock	ESA Status
Humpback Whale	10,103	Central North Pacific [4]	-
Minke Whale	1,233[2]	Alaska	-
Gray Whale	20,990[3]	Eastern North Pacific	-
Beluga Whale	340	Cook Inlet	Endangered
Killer Whale	2,347	Alaska Resident	-
Killer Whale	587	Alaska Transient	-
Harbor Porpoise	31,046	Gulf of Alaska	-
Dall's Porpoise	83,400	Alaska	-
Harbor Seal	22,900	Cook Inlet/Shelikof	-
Steller Sea Lion	55,422	Western U.S.	Threatened
Northern Sea Otter	15,090	Southcentral Alaska	-
Northern Sea Otter	47,676	Southwest Alaska	Threatened

[1] Allen and Angliss (2015)
[2] Zerbini et al. (2006)
[3] Carretta et al. (2015)
[4] In September 2016, NMFS de-listed the species, divided humpback whale into 14 DPSs, listed the Western North Pacific, Cape Verde Islands / Northwest Africa, Central America, and Arabian Sea DPSs as endangered, listed the Mexico DPS as threatened, and deemed the remaining 9 of the DPSs as not warranting listing.

Minke whales have historically been considered migratory in Alaska (Allen and Angliss, 2015) but recently they have been observed year-round in Cook Inlet off Cape Starichkof and Anchor Point, which are located approximately 56 miles and 63 miles south of the proposed Marine Terminal respectively (Owl Ridge, 2014). Humpback and gray whales use the lower Cook Inlet seasonally. The remaining species could be encountered at any time of the year. Observers recorded small numbers of humpback whales, minke whales, gray whales, killer whales, and Steller sea lions, and moderate numbers of harbor porpoises and harbor seals off Cape Starichkof between May and August 2013 during a marine mammal monitoring program (Owl Ridge, 2014). They also observed large numbers of sea otters. Sea otters are commonly found along the east side of Cook Inlet as far north as Clam Gulch, which is about 30 miles south of the Marine Terminal; however, they may move farther up the inlet as their population expands. The ESA threatened population of sea otters occurs along the western shore of lower Cook Inlet as far north as Tuxedni Bay (Redoubt Point), all of which is part of the Kodiak, Kamishak, Alaska Peninsula critical habitat unit for this listed stock (USFWS, 2009).

3.2 PRUDHOE BAY (BEAUFORT SEA)

Species of marine mammals most likely to be found in the West Dock area, at least seasonally, are the bowhead whale (*Balaena mysticetus*), beluga whale, ringed seal (*Phoca hispida*), spotted seal (*P. largha*), bearded seal (*Erignathus barbatus*), and polar bear (*Ursus maritimus*). Both gray and humpback whales have been found penetrating deeper into the Beaufort Sea in recent years (Green and Negri, 2005; Green et al., 2007; Hashagen et al., 2009), but not as far east as Prudhoe Bay. A humpback whale cow/calf pair was observed in Smith Bay, 75 miles west of the activity area (Hashagen et al., 2009), but this is considered an extralimital sighting. Other Alaskan marine mammals that might occur in the Beaufort Sea include the minke whale, harbor porpoise, killer whale, narwhal (*Monodon monoceros*), and ribbon seal (*Histriophoca fasciata*). Pacific walrus (*Odobenus rosmarus*) have been commonly observed in the Beaufort Sea near Barrow (Clarke et al., 2013). One walrus was observed offshore of Prudhoe Bay in November 2002 (Green et al., 2003), but they are not a regular inhabitant there. Killer whales have been observed off Point Barrow in recent years (G. Green, pers. obs.), but there are no recent records near Prudhoe Bay.

The estimated stock sizes of the six species most likely to occur in the vicinity of the activity area are found in Table 8. The likelihood of encountering summering bowhead and beluga whales would be considered low in the vicinity of the activity area, although an occasional bowhead whale could be encountered nearly anywhere in the Beaufort Sea (Moore et al., 2010). Beluga whales generally summer within the northern pack ice, but have been observed in small numbers along the Beaufort Sea coast during the summer months. The likelihood of observing beluga whales, as well as bowhead whales, in the activity area increases with the southern advance of the pack ice during fall. The fall migration of bowhead and beluga whales occurs through the Alaskan Beaufort Sea from late August to early October, with the peak movement occurring in September. However, nearly all migration occurs well offshore of the Prudhoe Bay Project area (Suydam et al., 2005; Treacy et al., 2006). Polar bears can be found in the vicinity of West Dock during both the summer and winter. Polar bears primarily come close to shore in Prudhoe Bay during winter when ice is present and ringed seals are more easily hunted. However, polar bears often get stranded along the coastal shorelines during summer, and spend much of their time wandering the beaches looking for beach-cast food items. These bears might pass West Dock during their wanderings.

Only polar bears and ringed seals are found in Prudhoe Bay during the winter.

Table 8. Marine Mammals of the Prudhoe Bay Region and Western and Central Beaufort Sea

Species	Stock Estimate	Stock	ESA Status [1]
Bowhead Whale	16,892	Western Arctic	Endangered
Gray Whale	20,990	Eastern North Pacific	-
Beluga Whale	39,258	Beaufort Sea	-
Beluga Whale	3,710	Eastern Chukchi Sea	-
Ringed Seal [1]	249,000	Alaska	-
Spotted Seal	460,268	Alaska	-
Bearded Seal [2]	155,000	Alaska	-
Pacific Walrus	129,000	Pacific	Candidate
Polar Bear	~900	Southern Beaufort Sea	Threatened

Source: Lunn et al. (2002), Bromaghin et al. (2015), Cameron et al. (2010), Conn et al. (2014), Allen and Angliss (2015), Carretta et al. (2015)

[1] Arctic ringed seal was listed as threatened. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of ringed seals under the ESA (Alaska Oil and Gas Association v. National Marine Fisheries Service et al., Case No. 4:14-cv-00029-RPB; North Slope Borough v. Pritzker et al., Case No. 4:15-cv-0000w-RPB; and State of Alaska v. National Marine Fisheries Service et al., Case No. 4:15-cv-00005-RPB). The consolidated decision vacated NMFS's listing of the Arctic ringed seal as a threatened species.

[2] Beringia Distinct Population Segment of the bearded seal was listed as threatened. On July 25, 2014, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of bearded seals under the ESA (Alaska Oil and Gas Association v. Pritzker, Case No. 4:13-cv-00018-RPB). The decision vacated NMFS's listing of the Beringia DPS of bearded seals as a threatened species. NMFS filed an appeal for that decision in May 2015.

3.3 NORTH PACIFIC, BERING SEA, AND CHUKCHI SEA VESSEL TRAFFIC

Tug and barge supply vessels would transport modules to West Dock over four seasons, during which they would travel through Alaskan waters of the North Pacific, Bering, Chukchi, and Beaufort Seas. Marine mammal species that could potentially be encountered during these transits are found in Table 9. Likelihood of encountering a given species varies greatly with location and season, as many of the species are ice dependent and occur at lower densities in open water habitats. While NMFS does not regulate vessel traffic under MMPA (S. Guan, pers. com. & Draft ITR Petition, AGDC 2017), vessel traffic would increase in the North Pacific, Bering Sea, and Chukchi Sea during construction of this Project. Sealifts to West Dock at 10 to 23 barges per year over four years may increase traffic in the Bering, Chukchi, and Beaufort Seas. The International Council on Clean Transportation (2015) reported that vessel traffic through the Bering Straits increased from 220 per year in 2008 to 440 in 2013, and predicted future growth.

LNGC routes to foreign markets would transit through lower Cook Inlet into the North Pacific. If the Great Circle Route to Asia is followed, then these carriers could enter the Bering Sea via Unimak Pass. LNGCs generally follow offshore routes and are less likely to encounter coastal species such as gray whales, harbor porpoise, harbor seals, and sea otters. Project-related LNGC trips may increase overall large vessel traffic along the potential LNGC routes in Cook Inlet and adjacent Gulf of Alaska by up to 50 percent, and large vessel traffic in the Gulf of Alaska and Bering Sea by as much as 9 percent (Resource Report 3, Appendix C Biological Assessment, Attachment 1).

Table 9. Marine Mammals Found in Alaskan Waters of the North Pacific, Bering and Chukchi Seas

Species	Stock Estimate	Stock	ESA Status	North Pacific	Bering	Chukchi
Bowhead Whale	16,892	Western Arctic	Endangered		x	x
Northern Right Whale	31	Eastern North Pacific	Endangered	x	x	
Blue Whale	1,647	Eastern North Pacific	Endangered	x	x	
Fin Whale	Unknown	Northeast Pacific	Endangered	x	x	x
Minke Whale	1,233	Kenai Fjords-Aleutians	-	x	x	x
Humpback Whale[1]	10,103	Central North Pacific	-	x	x	x
Humpback Whale [1]	1,107	Western North Pacific	Proposed Threatened	x	x	x
Gray Whale	20,990	Eastern North Pacific	-	x	x	x
Beluga Whale	39,258	Beaufort Sea	-		x	x
Beluga Whale	3,710	Eastern Chukchi Sea	-		x	x
Killer Whale	2,347	Alaska Resident	-	x	x	x
Killer Whale	587	Alaska Transient	-	x	x	x
Dall's Porpoise	83,400	Alaska	-	x	x	
Harbor Porpoise	48,215	Bering Sea	-	x	x	x
Ringed Seal [2]	249,000	Alaska	-		x	x
Spotted Seal	460,268	Alaska	-		x	x
Harbor Seal	22,900	Cook Inlet-Shelikof	-	x		
Harbor Seal	3,579	Aleutian Islands	-	x	x	
Harbor Seal	232	Pribilof Islands	-	x	x	
Harbor Seal	18,577	Bristol Bay	-		x	

Species	Stock Estimate	Stock	ESA Status	North Pacific	Bering	Chukchi
Harbor Seal	4,509	North Kodiak	-	x		
Harbor Seal	11,117	South Kodiak	-	x		
Bearded Seal [3]	155,000	Alaska	-		x	x
Pacific Walrus	129,000	Pacific	-		x	x
Steller Sea Lion	55,422	Western U.S.	Endangered	x	x	
Northern Fur Seal	648,534	Eastern North Pacific	-	x	x	
Polar Bear	~900	Southern Beaufort Sea	Threatened			x
Polar Bear	2,000	Chukchi/Bering Seas	Threatened		x	x
Northern Sea Otter	47,676	Southwest Alaska	Threatened	x	x	

Source : Lunn et al. (2002), Bromaghin et al. (2015), Zerbini (2006), Cameron et al. (2010), Conn et al. (2014), Allen and Angliss (2015), Carretta et al. (2015)

[1] In September 2016, NMFS proposed in April 2015 to divide humpback whale into 14 DPSs, and to de-listed the species 10, divided humpback whale into 14 DPSs, listed the Western North Pacific, Cape Verde Islands / Northwest Africa, Central America, and Arabian Sea DPSs as endangered, listed the Mexico DPS as threatened, and deemed the remaining 9 of the DPSs as not warranting listing

[2] Arctic ringed seal was listed as threatened. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of ringed seals under the ESA (Alaska Oil and Gas Association v. National Marine Fisheries Service et al., Case No. 4:14-cv-00029-RPB; North Slope Borough v. Pritzker et al., Case No. 4:15-cv-0000w-RPB; and State of Alaska v. National Marine Fisheries Service et al., Case No. 4:15-cv-00005-RPB). The consolidated decision vacated NMFS's listing of the Arctic ringed seal as a threatened species.

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4.0 STATUS AND DISTRIBUTION OF THE STOCKS OF MARINE MAMMALS LIKELY TO BE AFFECTED

4.1 COOK INLET

4.1.1 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; Angliss and Allen, 2014). In April of 2015, NOAA Fisheries proposed to revise the ESA listing for the humpback whale. They identified 14 Distinct Population Segments (DPS) and proposed to list 2 as threatened and 2 as endangered, and identify 10 others as not warranted for listing. The Central North Pacific stock of humpback whales will be included in the Hawaii Distinct Population Segment, and will no longer warrant listing under the ESA. This stock has recently been estimated at 10,103, with the portion of the stock that feeds in the Gulf of Alaska estimated at 2,845 animals (Allen and Angliss, 2015). The Central North Pacific stock winters in Hawaii and summers from British Columbia to the Aleutian Islands (Calambokidis et al., 1997), including Cook Inlet. Humpback use of Cook Inlet has been observed to be largely confined to lower Cook Inlet. They have been regularly seen near Kachemak Bay during the summer months (Rugh et al., 2005a). 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 these whales to visit the Marine Terminal construction area. However, because of a lack of food, humpbacks are unlikely to venture north into the proposed upper Cook Inlet pipeline crossings.

4.1.2 Minke Whale

Minke whales are the most common of the baleen whales world-wide. There are no population estimates for the entire North Pacific, but estimates have been made for some portions of Alaska. Zerbini et al. (2006) estimated the coastal population between Kenai Fjords and the Aleutian Islands at 1,233 animals.

Minke whales were encountered only twice (1998, 1999) during annual Cook Inlet-wide aerial surveys conducted from 1993 to 2004. Both times, the observations occurred off Anchor Point, located about 16 miles northwest of Homer, Alaska. A minke whale was also reported off Cape Starichkof in 2011 (A. Holmes, pers. comm.) and 2013 (E. Fernandez and C. Hesselbach, pers. comm.), suggesting this location is regularly used by a small number of minke whales, including the winter months. Several minke whales were also recorded off Cape Starichkof in early summer 2013 during exploratory drilling operations (Owl Ridge, 2014). There are no records of minke whales being observed in Cook Inlet north of Cape Starichkof. Occurrence of this species in upper Cook Inlet is considered unlikely; however, it is possible that minke whales occasionally travel as far north as the Marine Terminal construction area near Nikiski.

4.1.3 Gray Whale

Each spring, the Eastern North Pacific stock of gray whales migrate 4,971 miles northward from breeding lagoons in Baja California to feeding grounds in the Bering and Chukchi seas, reversing their travel again in the fall (Rice and Wolman, 1971). Their migration route is, for the most part, coastal until they reach the feeding grounds. A small portion of whales do not annually complete the full circuit, as small numbers can be found in the summer feeding along the Oregon, Washington, British Columbia, and Alaska coasts (Rice et al., 1984; Moore et al., 2007).

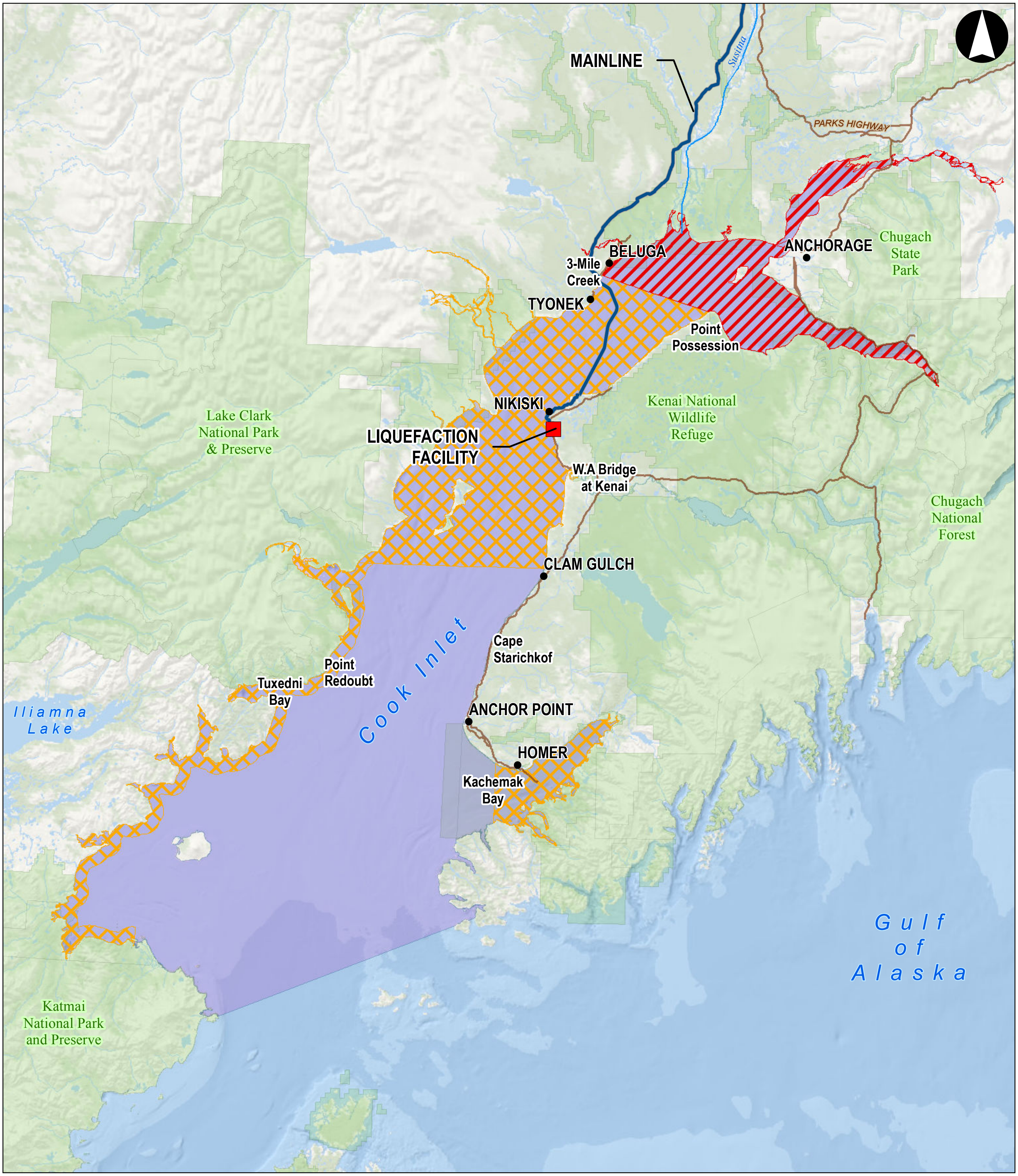
Human exploitation reduced this stock down to an estimated “few thousand” animals (Jones and Schwartz, 2002). However, by the late 1980s, the stock was appearing to reach carrying capacity and estimated to be at 26,600 animals (Jones and Schwartz, 2002). By 2002, the stock had been reduced to about 16,000 animals, especially following unusually high mortality events in 1999 and 2000 (Allen and Angliss, 2015). The stock has shown continuous growth since then and is currently estimated at 19,126 animals (Carretta et al., 2015).

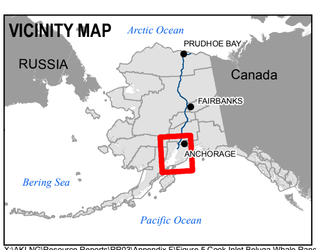
Most gray whales migrate past the mouth of Cook Inlet to and from northern feeding grounds, but small numbers of summering gray whales have been noted by fisherman near Kachemak Bay and north of Anchor Point. Gray whales were also seen offshore of Cape Starichkof in the summer of 2013 by marine mammal observers monitoring Buccaneer’s Cosmopolitan drilling program (Owl Ridge, 2014). Despite several sightings in lower Cook Inlet, gray whales are not expected to be encountered in upper Cook Inlet, where there are no records of gray whale occurrences. The most likely location gray whales could be encountered would be along the Kenai Peninsula south of Ninilchik, but it is possible that gray whales may occasionally travel as far north as Nikiski.

4.1.4 Beluga Whale

The Cook Inlet beluga whale DPS is a small, geographically isolated population separated from other beluga populations by the Alaska Peninsula. The population is genetically distinct from other Alaska populations, suggesting the Peninsula is an effective barrier to genetic exchange and that these whales may have been separated from other stocks at least since the last ice age (O’Corry-Crowe et al., 1997). Laidre et al. (2000) examined data from over 20 marine mammal surveys conducted in the northern Gulf of Alaska and found that sightings of belugas outside Cook Inlet were exceedingly rare, and these were composed of a few stragglers from the Cook Inlet DPS observed at Kodiak Island, Prince William Sound, and Yakutat Bay. Several marine mammal surveys specific to Cook Inlet (Laidre et al., 2000; Speckman and Piatt, 2000), including those that concentrated on beluga whales (Rugh et al., 2000, 2005a), clearly indicate that this stock is confined to Cook Inlet. There is no indication that these whales make forays into the Bering Sea where they might intermix with other Alaskan stocks.

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 in the 1990s. Between 1994 and 1998, the stock declined 47 percent, attributed to overharvesting by subsistence 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, with the most recent estimate at only 340 animals (Allen and Angliss, 2015). NMFS listed the population as “depleted” in 2000 as a consequence 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, NMFS designated critical habitat for the beluga under the ESA (Figure 5).





LEGEND

- Project Facility
- Alaska LNG Rev C2 Route
- Major Highways
- Major Rivers
- Cook Inlet Beluga Whale Range
- Beluga Whale Critical Habitat Area 1
- Beluga Whale Critical Habitat Area 2
- State and Federal Conservation Lands

0 10 20 40 Miles

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COOK INLET BELUGA WHALE RANGE AND CRITICAL HABITAT

FIGURE 5

X:\AKLNG\Resource Reports\RR03\Appendix F\Figure 5 Cook Inlet Beluga Whale Range and Critical Habitat.mxd

Prior to the decline, this DPS was believed to range throughout Cook Inlet and occasionally into Prince William Sound and Yakutat (Nemeth et al., 2007). However, the range has contracted coincident with the population reduction (Speckman and Piatt, 2000). 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 5). 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 (Critical Habitat Area 2; Figure 5).

Thus, beluga whales could be found in the vicinities of the pipeline crossings 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) suggest that beluga whale numbers in the vicinity of 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.

4.1.5 Harbor Porpoise

Harbor porpoise are small (4.9 feet in length), relatively inconspicuous toothed whales. The Gulf of Alaska Stock is distributed from Cape Suckling to Unimak Pass and was most recently estimated at 48,215 animals (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 Illiamna and Tuxedni bays on the west side of lower Cook Inlet (Rugh et al., 2005a; Shelden et al., 2014). None were recorded from near Nikiski during NMFS aerial surveys conducted between 1993 and 2012 (Shelden et al., 2014). Dahlheim et al. (2000) estimated the 1991 Cook Inlet-wide population at only 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. Because harbor porpoise have been observed throughout Cook Inlet during the summer months, they represent a species that could be encountered during both Marine Terminal construction and pipelay.

4.1.6 Dall's Porpoise

Dall's porpoises are widely distributed throughout the North Pacific Ocean, including areas offshore of Alaska, although they are not found in upper Cook Inlet or in the shallower waters of the Bering, Chukchi, and Beaufort Seas (Allen and Angliss, 2015). Compared to harbor porpoise, Dall's porpoise prefer deeper offshore and shelf slope waters. The Alaskan population has been estimated at 83,400 animals (Allen and Angliss, 2015), making it one of the more common cetaceans off the coast of Alaska. Dall's porpoise have been observed in lower Cook Inlet, including Kachemak Bay and near Anchor Point (Owl Ridge, 2014), but sightings in these areas are rare. There is a remote chance that Dall's porpoise might travel to the northern reaches of lower Cook Inlet, such as the Nikiski area.

4.1.7 Killer Whale

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). The resident stock is estimated at 2,347 animals and occurs from Southeast Alaska to the Bering Sea (Allen and Angliss, 2015). Resident whales feed exclusively on fish and are genetically distinct from transient whales (Saulitis et al., 2000). The transient whales feed primarily on marine mammals (Saulitis et al., 2000). The transient population inhabiting the Gulf of Alaska shares mitochondrial DNA haplotypes with whales found along the Aleutian Islands and the Bering Sea, suggesting a common stock, although there appears to be some subpopulation genetic structuring occurring to suggest that the gene flow between groups is limited (see Allen and Angliss, 2015). For the three regions combined, the transient population has been estimated at 587 animals (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., 2005a). 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. 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., 2005a). 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). These sporadic ventures of transient whales into 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). 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 encountering killer whales during vessel transits through lower Cook Inlet or the Bering Sea.

4.1.8 Steller Sea Lion

The Western Stock of the Steller sea lion is defined as all populations west of longitude 144°W to the western end of the Aleutian Islands (Loughlin, 1997). The most recent estimate for this stock is 55,422 animals (Allen and Angliss, 2015), considerably less than the estimated 140,000 animals in the 1950s (Merrick et al., 1987). Because of this dramatic decline, the stock was listed as threatened under the ESA in 1990, and was relisted as endangered in 1997. Critical habitat was designated in 1993, and is defined as a 20-nautical-mile radius around all major rookeries and haul out sites, none of which are located in Cook Inlet (NMFS, 1993).

The 20-nautical-mile buffer was established based on telemetry data that indicated these sea lions concentrated their summer foraging effort within this distance of rookeries and haul outs (NMFS, 1993). The upper reaches of Cook Inlet may not provide adequate foraging conditions for sea lions for establishing a major haul out presence. Steller sea lions feed largely on walleye pollock (*Theragra chalcogramma*), salmon (*Onchorhyncus spp.*), and arrowtooth flounder (*Atheresthes stomias*) during summer, and walleye pollock and Pacific cod (*Gadus macrocephalus*) during winter (Sinclair and Zeppelin, 2002), none of which, except for salmon, are found in abundance in upper Cook Inlet (Nemeth et al., 2007).

Steller sea lions inhabit lower Cook Inlet, especially in the vicinity of Shaw Island and Elizabeth Island (Nagahut Rocks) haul out sites just outside the inlet (Rugh et al., 2005a), but are rarely seen in upper Cook Inlet (Nemeth et al., 2007). Of the 42 Steller sea lion groups recorded during Cook Inlet aerial surveys between 1993 and 2004, none were recorded north of Anchor Point and only one in the vicinity of Kachemak Bay (Rugh et al., 2005a). Marine mammal observers associated with Buccaneer’s drilling project off Cape Starichkof did observe seven Steller sea lions during the summer of 2013 (Owl Ridge, 2014), thus there is a small chance that this species could occasionally occur near the proposed construction areas.

4.1.9 Harbor Seal

At over 150,000 animals state-wide (Allen and Angliss, 2015), harbor seals are one of the more common marine mammal species in Alaskan waters. They are most commonly seen hauled out at tidal flats and rocky areas. Harbor seals feed largely on schooling fish, such as walleye pollock, Pacific cod, salmon, Pacific herring, eulachon, and squid. Although harbor seals may make seasonal movements in response to prey, they are resident to Alaska and do not migrate.

The Cook Inlet/Shelikof Stock, ranging from approximately Anchorage down along the south side of the Alaska Peninsula to Unimak Pass, has been recently estimated at a stable 22,900 seals (Allen and Angliss, 2015). Large numbers concentrate at the river mouths and embayments of lower Cook Inlet, including the Fox River mouth in Kachemak Bay (Rugh et al., 2005a). 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., 2005a; 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. During summer, small numbers of harbor seals are expected to occur in the vicinity of both the Marine Terminal construction area near Nikiski, and along the proposed Mainline pipeline crossing route.

4.2 CHUKCHI AND BEAUFORT SEA

4.2.1 Bowhead Whale

The Western Arctic stock of bowhead whale is one of five stocks recognized by the International Whaling Commission (IWC), and is currently the largest with an estimated population of 16,892 animals (Allen and Angliss, 2015). This stock is currently listed as endangered under the ESA and depleted under the MMPA, although it has experienced significant growth in the past 30 years concurrent with subsistence harvests conducted under an IWC quota system (Givens et al., 2013).

This stock summers in the Canadian Beaufort Sea, migrates through the Alaskan Beaufort Sea, Chukchi Sea, and Bering Strait in the spring and fall, and winters in the Bering Sea (Braham et al., 1984; Brueggeman, 1982; Moore and Reeves, 1993). The whales pass through the Chukchi Sea, often following a route along the Siberian coast (Quakenbush, 2007; Quakenbush, et al. 2010). The whales follow open leads in the sea ice during their spring migration (March to mid-June) back to Canada (Braham et al., 1984; Moore and Reeves, 1993). Bowhead whales were acoustically detected from 2007 to 2011 in the Chukchi Sea from April until January, with peaks in occurrence from April to June and September to December, coinciding with the spring and fall migrations, respectively (Hannay et al. 2013). However, individual bowhead whales can be found throughout their range at almost any time of the year (Rugh et al., 2003; Moore et al., 2010), and they have been found summering near Point Barrow and Smith Bay (Green and Negri, 2005; Green et al., 2007). Mocklin et al. (2012) have reported on bowheads feeding near Point Barrow.

Pre-whaling population estimates for bowhead whales range between 10,400 and 23,000 animals. This population was reduced to approximately 3,000 whales by commercial whaling (Woodby and Botkin, 1993). From 1978 to the early 2000s, the bowhead whale population grew at an annual rate of approximately 3.2 to 3.4 percent (George et al., 2004).

Bowhead whales are hunted for subsistence purposes in the Chukchi and Bering Seas by whalers from the Villages of Barrow, Wainwright, Point Hope, Kivalina, Little Diomede, Wales, Savoonga, and Gambell. Typically, bowhead harvests for Point Hope, Point Lay, and Wainwright occur during the Spring migration from early May to early June; although, some successful Fall whaling has been conducted by Wainwright in recent years (Shell, 2013).

Bowhead whales are hunted in the Alaskan Beaufort Sea by whalers from the Villages of Kaktovik, Nuiqsut, and Barrow. Barrow hunts for bowheads in the spring and fall. The Nuiqsut hunters base from Cross Island, 17 miles northeast of Prudhoe Bay, and hunt only in the fall. Fall migrating whales typically reach Cross Island in September and October (Brower, 1996); although, some whales might arrive as early as late August. Most bowheads migrate during fall through the Alaskan Beaufort in water depths between 49 and 656 feet deep (Miller et al., 2002; Treacy et al., 2006), with annual variability depending on ice conditions (whales traveling farther offshore during heavy ice cover years). Hauser et al. (2008) conducted surveys for bowhead whales near the Colville River Delta during August and September 2008, and found most bowheads between 15.5 and 19 miles north of the barrier islands (Jones Islands), with the nearest in 59 feet of water about 15.5 miles north of the Colville River Delta. Waters less than 5 yards deep are considered too shallow to support these whales, and in three decades of aerial survey by the Bureau of Ocean Energy Management ([BOEM], formerly Materials Management Service), no bowhead whale has been recorded in waters less than 16 feet deep (Clarke and Ferguson, 2010). The West Dock activities would occur in waters less than 14 feet. Also, both locations are inside the barrier islands (south of the Midway Islands), where bowhead whales are rarely observed (Treacy et al, 2006). Migrating bowheads could be encountered by barging traffic to West Dock during the fall, but encounters could be limited by following nearshore traffic routes.

4.2.2 Gray Whale

The Eastern North Pacific (or California) gray whale is one of two stocks inhabiting the Pacific Ocean (the other is the endangered western North Pacific [or Korean] stock found along the Asian coast). The eastern North Pacific stock breeds in the warm-water lagoons of coastal Baja California and Mexico, and winters in the shelf waters of the Bering and Chukchi seas (Jones et al., 1984), completing an annual round-trip migration of 9,942 to 13,981 miles each year. Not all whales complete the migration as some whales feed in the coastal waters of the Pacific Northwest (Calambokidis, 2002, 2010), and possibly elsewhere along the migration route.

Gray whales have been acoustically detected in the northeastern Chukchi Sea from late July through late October. (Hannay et al. 2013). Gray whales were the most commonly sighted cetacean species in summer (Clarke and Ferguson, 2010; Ireland et al., 2009; Aerts et al., 2013). Recent evidence indicates that the Chukchi Sea has replaced the northern Bering Sea as the preferred feeding area for gray whales because amphipod biomass has decreased in the latter area (Bluhm et al., 2007; Coyle et al., 2007; Moore et al., 2003)

Prior to 1997, reports of gray whales in the Beaufort Sea were very rare. A single gray whale was killed at Cross Island in 1933 (Maher, 1960), and small numbers were observed in the Canadian Beaufort Sea approximately 700 coastal miles east of Point Barrow in 1980 (Rugh and Fraker, 1981). Only one gray whale was observed during extensive aerial surveys conducted in the Beaufort Sea between 1979 and 2009 (Clarke and Ferguson, 2010). Sightings in the Beaufort Sea became more common, although still occasional, from 1998 to 2004 (Miller et al., 1999; Treacy, 2000; Williams and Coltrane, 2002), and then regular from 2005 on (Green and Negri, 2005; Green et al., 2007; Jankowski et al., 2008; Lyons et al., 2009). Green and Negri (2005) observed feeding gray whales near Elson Lagoon (immediately east of Point Barrow) in 2005, and Green et al. (2007) at Smith's Bay (approximately 62 miles east of Point Barrow) in 2007. Still, few gray whales have ever been reported in the Beaufort Sea as far east as Cape Halkett (approximately 99 miles east of Point Barrow). Their occurrence within Prudhoe Bay is not expected.

4.2.3 Beluga Whale

The Eastern Chukchi Sea stock of beluga whales is one of five stocks occurring in Alaska (O'Corry-Crowe et al., 1997). Current population of the Eastern Chukchi Sea stock is still being evaluated by the Alaska Beluga Whale Committee, and was due to be published in 2015, but not yet publically available (NMFS, 2014). Belugas winter in the Bering Sea and then migrate through the Chukchi Sea to the Beaufort. Some beluga whales migrate north during April through June (Moore et al., 1993), while others congregate in nearshore areas of the Chukchi Sea near Omalik and Kasegaluk lagoons in late June and early July (Huntington et al., 1999; Suydam et al., 2001b) before moving north. Eastern Chukchi beluga were detected acoustically from mid-July until the end of August 2007 almost exclusively off Barrow, and primarily within Barrow Canyon (Suydam et al., 2001, 2005). Beluga detections were much more common in the spring. Large differences in the number of detection days between years are attributed to variations in migration routes due to differing ice conditions. Spring migrating beluga are commonly observed with bowhead in nearshore leads that form in the spring between Cape Lisburne and Point Barrow (Moore and DeMaster, 1998),

The population of the Beaufort Sea is currently estimated to be 39,258 animals (Allen and Angliss, 2015). However, this estimate is based on aerial surveys conducted in 1992 and includes a smaller, more conservative correction factor (to account for availability bias) than has been used for other estimates from aerial surveys of this species in Alaska (Frost and Lowry, 1995; Allen and Angliss, 2015). The current population trend is unknown, but subsistence harvest is probably well below the potential biological removal (Allen and Angliss, 2015).

Like all Alaska stocks (except the Cook Inlet stock), the Beaufort Sea stock winters in the open leads and polynyas of the Bering Sea (Hazard, 1988). In the spring, they migrate through coastal leads over 1,242 miles to their summering grounds in the Mackenzie River delta where they molt, feed, and calve in the warmer estuarine waters (Braham et al., 1977). In late summer, these belugas move into offshore northern waters to feed (Davis and Evans, 1982; Harwood et al, 1996; Richard et al, 2001). In the fall, they begin their migration back to the wintering grounds, generally following an offshore route as they pass through the western Beaufort Sea (Richard et al., 2001).

Richard et al. (2001) tracked 12 satellite-tagged belugas and found them to pass relatively quickly (average 15 days) through the Alaskan Beaufort Sea during September. The westward routes ranged from coastal to over 404 miles offshore with all but one beluga passing at least 62 miles north of the Beaufort shoreline. Based on the previously mentioned surveys, and results from numerous aerial and boat-based marine mammal surveys in the Beaufort Sea, some belugas take a more coastal route during their fall migration, but compared to the population vanguard and the survey effort expended, nearshore travel appears to be relatively rare. Most belugas recorded during aerial surveys conducted in the Alaskan Beaufort Sea in the last two decades were found over 40 miles from shore (Miller et al., 1999; Funk et al., 2008; Christie et al., 2010; Clarke and Ferguson, 2010; Brandon et al., 2011).

The Eastern Chukchi Sea beluga whale stock also occurs in the Beaufort Sea during the late summer and fall (Suydam et al.; 2005). Suydam et al. (2005) satellite-tagged 23 beluga whales in Kasegaluk Lagoon and found nearly all the whales moved into the deeper waters of the Beaufort Sea post-tagging. However, virtually none of the whales were found in continental shelf waters (<656 feet deep) of the Beaufort Sea, and all were in waters at least 40 miles north of Prudhoe Bay.

Few surveys have reported belugas close to shore where the planned construction activities would occur. In 2005, Green and Negri reported small beluga groups nearshore Cape Lonely (August 26) and in Smith Bay (September 4). Funk et al. (2008) reported a group just offshore of the barrier islands near Simpson Lagoon, while Aerts et al. (2008) reported summer sightings of three groups of eight animals inside the barrier islands near Prudhoe Bay. Lomac-McNair (2014) recorded 15 beluga whales while monitoring July to August seismic survey activity offshore Prudhoe Bay. Thus, it is possible for beluga whales to occur in the vicinity of the planned dock modification during summer and fall periods of operation, but occurrences would be relatively rare.

4.2.4 Ringed Seal

Ringed seals are one of the most common marine mammals in the Beaufort, Chukchi, and Bering seas. This Alaskan stock, a subpopulation of the Arctic subspecies (*P. h. hispida*), was most recently estimated at 249,000 animals (Allen and Angliss, 2015), although historic estimates have ranged as high as 3.6 million (Frost et al., 1988). Some taxonomists have placed this seal in the genus *Pusa*, following Rice (1998), but that usage is not universal. Ringed seals were listed as a threatened species under the ESA effective February 2013 due to diminishing snow and ice attributed to climate change; however, NMFS's rule for the listing was litigated and on March 11, 2016, the U.S. District Court for the District of Alaska vacated the listing, remanding the rule back to NMFS.

During the open-water season, ringed seals are widely dispersed as single animals or in small groups and they are known to move into coastal areas (Smith, 1987; Harwood and Stirling, 1992; Moulton and Lawson, 2002; Green et al., 2007). During the open-water period, ringed seals shift from feeding on Arctic cod associated with sea ice to Saffron cod, shrimp, euphausiids, and amphipods. They were commonly recorded during previous surveys close to the Beaufort Sea coast (Green et al., 2007; Hauser et al., 2008; Brandon et al., 2011), and are expected to be present in Prudhoe Bay throughout the open water period, including during dock modification activities.

They survive the winter by digging multiple haul-out shelters and nursery lairs beneath the snow (Kelly, 1988). A loss of snow cover, and ice coverage in general, poses a risk to long-term survival (Kelly et al., 2010). Winter densities are low nearshore because of grounded ice limiting available water habit. During the sea ice period, ringed seals rest in subnivean (under snow) lairs. Pupping occurs within these lairs during March and April (Kelly et al., 2010). Pupping activity is not expected to occur in the vicinity of West Dock because of shallow water depths, although winter lair records by Williams et al. (2006) indicate some use in relatively shallow Prudhoe Bay waters.

NMFS proposed critical habitat for the ringed seal on 3 December 2014 (FR 79:71727). The proposed critical habitat included all of the Beaufort Sea and Chukchi Sea within the U.S. EEZ and most of the Bering Sea north of latitude 59 degrees. No further action on the proposed critical habitat has been taken by the agency since that time.

4.2.5 Spotted Seal

The spotted seal is found from the Beaufort Sea to the Sea of Japan and is most numerous in the Bering and Chukchi seas (Quakenbush, 1988), although small numbers do range into the Beaufort Sea during summer (Rugh et al., 1997; Lowry et al., 1998; Green et al., 2007). The Bering Sea wintering population has been estimated at 200,000 to 250,000 (Bigg, 1981), with a more recent estimate of 460,268 (Conn et al., 2014). A status review of the species was completed in 2009 (Boveng et al., 2009) after the spotted seal was petitioned for listing under the ESA relative to climate change and its effects on sea ice. The review found that listing was not warranted.

Pupping occurs along the Bering Sea ice front during March and April, followed by mating and molting in May and June (Quakenbush, 1988). During the summer, they follow the retreating ice north into the Chukchi and Bering seas, and then begin hauling out on lagoon and river delta beaches during the open water period. Several thousand spotted seals use Kasegaluk Lagoon in the eastern Chukchi Sea at that time. They begin their migration back to Bering Sea wintering grounds in October (Lowry et al., 1998).

Relatively few spotted seals summer in the Beaufort Sea, where they haulout at Oarlock Island, the Piasuk River, and the Colville River Delta (Green et al., 2007). The Colville River Delta and nearby Sagavanirktok River supported as many as 400 to 600 spotted seals, but in recent times fewer than 20 seals have been seen at any one site (Johnson et al., 1999). Spotted seals were recorded during three years (2005 to 2007) of barging activities between Prudhoe Bay and Cape Simpson (Green and Negri, 2005, 2006; Green et al., 2007). They observed between 23 and 54 seals annually, with the peak distributions found off the Colville and Piasuk rivers. Similarly, Savarese et al. (2010) surveyed the central Beaufort Sea from 2006 to 2008 and recorded 59 to 125 spotted seals annually. Summer use of the Beaufort Sea by spotted seals may be higher than haul out counts indicate, although no haul out site surveys have been conducted in recent years.

Lomac-MacNair et al. (2014) observed 37 spotted seals in Prudhoe Bay (and another 39 that were either spotted or ringed seals), including several in the immediate vicinity of West Dock, while monitoring July-August seismic activity. Spotted seals seasonally leave the Beaufort Sea to winter in the Bering Sea.

4.2.6 Bearded Seal

The Alaska stock of bearded seals is found seasonally in the shallow shelf waters of the Beaufort, Chukchi, and Bering seas (Cameron et al., 2010). They are closely associated with ice, preferring to winter in the Bering Sea and summer along the pack ice edge in Chukchi Sea, although many summer in nearshore waters of the Beaufort Sea. Bearded seals prefer areas of 70 to 90 percent ice coverage, but unlike ringed seals, few bearded seals overwinter in the Chukchi and Beaufort seas (Allen and Angliss, 2015). Pupping occurs on ice floes, primary in May, in the Bering and Chukchi seas.

Bearded seals have not experienced any noted decline, but their seasonal dependence on ice makes them vulnerable to declining ice conditions due to climate change (Cameron et al., 2010). As a consequence, they were listed under the ESA in December, 2012, but the decision was overturned in 2014 because the U.S. District Judge ruled that NMFS failed to identify threats to the bearded seal in the “reasonably foreseeable future.” There is no reliable population estimate for bearded seals. Cameron et al. (2010) provided a conservative estimate for the Beringia DPS (the population that winters in the Bering and Chukchi seas) of 155,000, based on data collected over the last four decades.

Bearded seals are a common inhabitant of the central Beaufort Sea (Treacy, 2002a, 2002b; Moulton et al., 2003; Green and Negri, 2005, 2006; Green et al., 2007; Funk et al., 2008; Hauser et al., 2008; Savarese et al., 2010; Brandon et al., 2011; Reiser et al., 2011; Clarke et al., 2011), but especially when ice coverage is about 70 to 90 percent. Based on surveys in the Prudhoe Bay area during the open-water period, only very small numbers of bearded seals would be expected in the vicinity of the proposed activities.

4.2.7 Polar Bear

Polar bears are protected under provisions of the MMPA and were listed as a threatened species under the ESA in 2008. In 2010, USFWS designated nearly 187,260 square miles of onshore barrier islands, terrestrial denning habitat, and offshore sea-ice as critical habitat. Of the three stocks of polar bears occurring in the Beaufort Sea, members of the Southern Beaufort Sea stock are the bears most likely to occur in Prudhoe Bay (Amstrup, 2003; Bethke et al., 1996; Schliebe et al., 2006). Earlier, Regehr et al. (2006) estimated that stock at 1,526 bears, but from 2004 through 2006, this stock declined by about 25 to 50 percent and then stabilized at about 900 animals by 2010 (Bromaghin et al., 2015).

Polar bears are principally dependent on sea ice to provide a substrate on which to travel, rest, and hunt for their principal prey–ringed seals. Most bears seasonally follow the retreat of the sea ice, although some females will den on shore and other bears occasionally become stranded on the beach (Amstrup and DeMaster, 1988; Stirling, 1988). Polar bears are increasingly found on the mainland and barrier islands in late summer and fall, often coincident with the fall bowhead hunt, when whale carcass remains are available (Schliebe et al., 2008). During fall aerial surveys along the Alaskan Beaufort Sea coast since 2000, Gleason and Rode (2009) annually counted between 50 and 125 bears on the beach. These bears frequently wander through the West Dock Project area.

Polar bears den both on land and over ice in the general region of Prudhoe Bay and Point Thomson, and may den along the Beaufort Sea coast wherever deep snow drift conditions conducive to denning are present (Amstrup and Gardner, 1994; Fischbach et al., 2007; Durner et al., 2010, 2013). Historically, terrestrial polar bear dens have occurred a minimum of 6 miles to the east of the GTP, and 15 miles to the west of the GTP (USGS, 1910-2010). One occurrence of a polar bear near GTP infrastructure occurred in 2015 near the Oxbow landfill, approximately 2 miles south of the GTP and less than 0.5 mile from pipeline infrastructure. Avoidance measures, such as the conduct of forward-looking infrared radar (FLIR) surveys, would be used to detect existence of denning bears and avoid disturbance.

In 2010, USFWS designated nearly 187,260 square miles of Polar Bear critical habitat comprised of onshore barrier islands, denning areas, and offshore sea-ice habitat, terrestrial denning habitat, and barrier islands as critical habitat. Parties challenged the critical habitat designation, and the district court vacated the designation in its entirety. Alaska Oil & Gas Association v. Salazar, 916 F. Supp.2d 974 (D. Alaska 2013). However, in February 2016, the Ninth Circuit reversed the district court's decision and remanded the case to the court for entry in favor of USFWS (Alaska Oil & Gas Association v. Jewel, No. 13-35619, 9th Cir. 2016) and the critical habitat designation has been reinstated. A portion of the Project area within Polar Bear critical habitat. This includes all Project components within 25 miles of the Beaufort Sea coastline (GTP, Mainline, PTTL, and PBTL) and offshore waters of the Chukchi Sea and Beaufort Sea (vessel routes to Prudhoe Bay and work at West Dock). This assessment would be revised should additional litigation result in a change in the critical habitat designation.

4.3 NORTH PACIFIC AND BERING SEA

All nine species mentioned for Cook Inlet also occur in the North Pacific and Bering Sea, while all seven species mentioned for the Beaufort Sea also occur in the northern Bering Sea, especially during the winter when sea ice has driven them out of the Beaufort Sea. Species not found in abundance in either Cook Inlet or the Beaufort Sea, but that do occur along other segments of the vessel routes include the northern right whale, blue whale, fin whale (*Balaenoptera physalus*), and northern fur seal.

5.0 PROJECT RISK FACTORS

Project risk factors associated with the construction and operation of the Project that could affect marine mammals include:

- Exposure to harassment level underwater sound associated with impulsive noise generating activities, such as impact hammer pile driving;
- Exposure to harassment level underwater sound associated with non-impulsive (continuous) noise generating activities, such as vibratory hammer pile driving, and noise associated with vessel thruster cavitation, pipelay activities, and dredging;
- Exposure to harassment level airborne sound associated with pile driving activity (hauled out pinnipeds only);
- Habitat modification from dredging;
- Ship strikes; and
- Habitat contamination from accidental spills of fuels.

Each is discussed separately in the following sections.

5.1 NOISE HARASSMENT

5.1.1 Exposure Criteria Thresholds

NMFS and USFWS have established disturbance and injury thresholds relative to the impacts of noise on marine mammals (Table 10), which are the basis for assessing potential sound level impacts. Project-related actions with the potential to cause airborne noise generating disturbance to hauled out pinnipeds include pile driving associated with the Marine Terminal construction and modifications at West Dock. Impact pile driving is an impulsive source, while vibratory pile driving, dredging, and thruster operation in general are continuous (non-impulsive) sources.

Table 10. Marine Mammal Injury and Disturbance Thresholds for Underwater and Airborne Sound

Marine Mammals	Airborne Sound Levels from Marine Construction Activity [1] Level at which Pinniped Haul-out Disturbance has been Documented [1]	Continuous Sound Disturbance Threshold	Impulsive Sound Disturbance Threshold	Injury Threshold
Cetaceans	N/A	120 dB rms	160 dB rms	180 dB rms
Pinnipeds	90 dB rms (unweighted) for harbor seals 100 dB rms (unweighted) for all other pinnipeds re: 20 µPa	120 dB rms	160 dB rms	190 dB rms

[1] NMFS established and used criteria / airborne thresholds e.g. Federal Register 76(24)6410

5.1.2 Impulsive Underwater Noise

Impulsive underwater sound generated by construction activities has the potential to harass marine mammals where it exceeds 160 dB re 1 µPa (rms). Impulsive noise sources proposed for the construction phase of the Project include impact hammer sound associated with pile driving. Pile driving is planned for the construction of the MOF and PLF trestle, and includes the driving of pipe piles, sheet piles, bent piles, and dolphins. Pile driving is also expected to occur with the construction of the MOF on the west side of Cook Inlet. The expansion of West Dock would involve driving pipe piles, sheet piles, and H-piles. Presumably, most of these piles would be placed using an impact hammer.

Illingworth and Rodkin (2007) compiled measured data on near-source (11-yard) sound pressure levels from impact pile driving for pile sizes ranging in diameter from 12 to 96 inches (Table 11). Near-source values ranged from 170 dB re 1 µPa (24-inch concrete pile) to 205 dB re 1 µPa (96-inch cast-in-steel shell pile). Distances to the 180-dB injury threshold for cetaceans ranged between 13 and 584 feet, and to the 160-dB harassment threshold from 105 feet to 65 miles.

Table 11. Near-Source Sound Pressure Levels from Impact Pile Driving

Pile Type	Pile Size	Approx. Water Depth	[1]SPL (rms)	Radius (yards) [2]		
				190 dB	180 dB	160 dB
Steel H-type	12-inch	5.5 yd	183	5.5	16	155
Steel Sheet	24-inch	16 yd	190	11	35	347
Concrete	24-inch	5.5 yd	170	0	4	35
Concrete	24-inch	16 yd	176	2	8	70
Steel Pipe	12-inch	5.5 yd	177	3	9	78
Steel Pipe	14-inch	16 yd	184	7	17.5	174
Steel Pipe	24-inch	16 yd	194	17.5	56	549
Steel Pipe	24-inch	5.5 yd	190	11	35	347
Steel Pipe	36-inch	5.5 yd	190	11	35	347
Steel Pipe	36-inch	11 yd	193	16	49	489
Cast-in-Steel Shell	60-inch	5.5 yd	195	20	62	616
Cast-in-Steel Shell	96-inch	11 yd	205	62	195	1,947

[1] Near source is approximately 33 feet
[2] Compiled by Illingworth and Rodkin (2007)

These near-source values are less than those measured by Blackwell (2005) during pile driving of 36-inch steel pipe at Port MacKenzie dock in upper Cook Inlet. Blackwell (2005) found SPL (rms) levels to be 190 dB re 1 µPa at 67.8 yards, which equates to about 205 dB re 1 µPa at 10.9 yards, or about 12 to 15 dB higher than for similar sized pile from Illingworth and Rodkin (2007; Table 11). Blackwell (2005) estimated the distance to the 180 dB isopleth at 273.4 yards (deep hydrophone), based on a transmission loss model of 222.0 – 17.5 Log (r). The same model suggests a distance of 2.2 miles to the 160 dB threshold.

URS (2007) conducted a test pile driving program at Anchorage in 2007 in association with the Port of Anchorage's Marine Terminal development project, where they evaluated the sound pressure levels associated with impact driving of H piles. Received SPLs ranged from 160 dB re 1 µPa (rms) at 328 yards to 177 dB re 1 µPa (rms) at 20.8 yards, and are much less than what Blackwell (2005) measured during impact hammer pile driving at Port Mackenzie. However, the difference is probably attributable to the size of the piles. The URS study measured the driving of 14-inch H-piles, while Blackwell measured the deep driving of 36-inch pipe.

SFS (2009) conducted additional acoustical measurements of impact driving sheet pile at the Port of Anchorage in 2008. They estimated the maximum SPL 1-yard source at 199.73 dB and the distance to the 160-dB isopleth at 106 yards, based on a 20 Log (r) spreading model. Again, this was much less than Blackwell's (2005) measurements of a 36-inch round pile.

In August 2013, Illingworth and Rodkin (2014) measured underwater noise levels associated with driving (impact hammer) conductor pipe at an exploratory well site in lower Cook Inlet. Measurements were taken at distances between 59 yards and 0.8 mile. The relationship between the received sound levels and distance indicated a transmission loss of about 20.4 Log (r), with an estimated distance to the 160 dB threshold of about 1.01 miles.

Zykov and Warner (2013) modeled potential underwater sound levels associated with the proposed pile driving activity during construction of the Chuitna port facilities in upper Cook Inlet near Tyonek. They modeled 20 different pile driving scenarios based on facility type (bulkhead island, nearshore elevated conveyor, mid-water elevated conveyor, offshore ship-loading dock, and offshore fender piles), hammer type (impact and vibratory), and hammer power (average and maximum). Model results (Appendix A) showed that source sound levels and propagation distances were greater for activities requiring a larger hammer (to drive larger piles) and those farther offshore. Impact hammer model results were also significantly higher than when applying a spherical spreading model to the data compiled by Illingworth and Rodkin (2007) or the results from Blackwell (2005). Average modeled distances to the 160 dB isopleth ranged between 2.53 and 4.49 miles, while maximum distances ranged between 4.47 and 12.15 miles (Table 12). Based on their models, the impact pile driving noise levels exceeding 180 dB re 1 µPa (the cetacean threshold for Level A injury) could extend from 336.8 yards to 0.948 mile. (Table 12).

As noted earlier, the radii to threshold from the Illingworth and Rodkin (2007) data were determined by applying a 20 Log (r) spherical transmission loss model to Illingworth and Rodkin's compiled near-source (10.9-yard) SPL data, while Illingworth and Rodkin (2014) showed a similar 20.4 Log (r) transmission loss. Blackwell (2005) applied a higher source value with a 17.5 Log (r) transmission loss model. Zykov and Warner (2013) predicted transmission loss using JASCO's Marine Operations Noise Model (MONM), which "computes received per-pulse SEL for directional sources at a specified depth" following a parabolic equation method for frequencies less than 2 kilohertz and a Gaussian beam ray-trace model for frequencies above 2 kilohertz. It is unclear from the published reports why the MONM predicts such greater radii at distance from the source. Given that Illingworth and Rodkin (2014) and Blackwell (2005) measured sound levels at distances to 0.81 and 1.17 miles from the source, respectively, their results may better reflect the distance to the 160 dB isopleth compared to the Zykov and Warner (2013) values that are fully modeled and not based on any measurements at distance.

In general, SPLs exceeding 160 dB from impact driving of round piles appear to range between about 0.6 and 2.5 miles based on empirical field data, while SPL radii from driving of sheet or H-piles are less than 328 yards, without any mitigation measures.

Table 12. Modeled Sound Exposure Levels from Impact Pile Driving in Cook Inlet

Pile Size [1]	Power	Modeling Water Depth	SEL [2]	Radius (yards) without mitigation [2]		
				190 dB	180 dB	160 dB
24-30 inches	Average	11 yd	200.6	116	426.5	4,141.5
24-30 inches	Maximum	11 yd	202.3	220	761	7,876
30-36 inches	Average	12 yd	202.3	158.5	546	5,467
30-36 inches	Maximum	12 yd	204.2	301	928	10,952.5
36-48 inches	Average	13 yd	204.2	195	647	7,918
36-48 inches	Maximum	13 yd	206.8	437	1,125	18,263
48-60 inches	Average	26 yd	204.2	116	549	6,917
48-60 inches	Maximum	26 yd	209.7	435	1,668	21,379
48-60 inches[1]	Average	26 yd	200.6	66	337	4,445.5
48-60 inches[1]	Maximum	26 yd	205.3	203	897	13,033

[1] Fender piles

[2] Modeled sound exposure levels (SELs dB re 1 µPa2·s) and isopleth radii for pile driving in Upper Cook Inlet from Zykov and Warner 2013 (Appendix A)

5.1.3 Non-Impulsive Underwater Noise

5.1.3.1 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.

In 2005, Laughlin (2010a) collected underwater noise measurements in association with vibratory driving of 24-inch steel piles at a ferry terminal in Puget Sound, and recorded a near-source (11-yard) SPL of 162 dB re 1 µPa (rms) with dominant frequencies between 800 and 1,000 hertz.

In 2009, Laughlin (2010b) again measured underwater noise associated with the vibratory hammering of 30-inch steel piles at a second ferry terminal. Here, the average SPLs ranged between 160 and 169 dB re 1 µPa (rms) at distances between 12 and 17.5 yards from the source, with a maximum value of 169 dB re 1 µPa (rms) at 12 yards. Laughlin (2010b) also measured sound levels at 864 and 881 yards from source and recorded SPLs of between 126 and 131 dB re 1 µPa (rms). The measured transmission losses ranged between 29 and 43 dB re 1 µPa (rms) (averaging 34 dB re 1 µPa (rms)) over the approximate 875-yard range between source and received levels. Laughlin (2010b) concluded that the observed transmission loss was most accurately modeled by a logarithmic spreading loss of about 20 Log (r).

In 2004, Blackwell (2005) measured underwater noise associated with the vibratory driving of two 36-inch piles at the Port MacKenzie dock in Cook Inlet, Alaska, and recorded mean SPLs of 162 and 164 dB re 1 µPa (rms) (at 61 yards from the source), depending on microphone depth (1.6 and 11 yards, respectively). Dominant frequency ranged between 400 and 2,500 hertz. Blackwell also characterized the noise propagation associated with hammering and calculated a logarithmic transmission loss of about 21.8 Log (r) for the deeper hydrophone and about 28 Log (r) for the shallower hydrophone. The transmission loss was greater near the surface, probably due to interference from surface waves.

Carr et al. (2006) assessed underwater noise impacts associated with development of the Cacouna Energy Liquefied Natural Gas terminal in Haro Strait, British Columbia. They measured transmission loss of experimentally transmitted sound levels (at the center of the 1/3 octave bands ranging from 200 to 2,000 hertz) from six locations at distances between 912 and 3,552 yards from the sound source. Using vibratory hammer source data from Nedwell and Edwards (2002) (the loudest measurement was 151 dB re 1 µPa (rms) at 87.5 yards from the source; pile size was not given, but the photographs suggest 36-inch steel), Carr et al.'s (2006) modeled distance to the 120 dB re 1 µPa (rms) isopleth was 0.99 mile.

The results of the URS (2007) study are directly applicable to planned construction at the Project Marine Terminal, and indicate that for vibratory pile driving the radial distance to the 120 dB isopleth was about 875 yards. URS found, as did Blackwell (2005), that noise levels emanating from vibratory pile driving in the silty nearshore waters of Cook Inlet drop off rapidly.

SFS (2009) measured vibratory pile driving activity at the Port of Anchorage and found maximum source (1.09 yards) levels to range between 161 and 198 dB re 1 µPa (rms), depending on pile type. Average source values ranged between 158 and 187 dB re 1 µPa (rms). Sheet pile placement generated the greatest noise levels, with the average distance to the 120 dB threshold estimated at 1.4 miles and the maximum distance estimated at 5.1 miles. The maximum distance measurement occurred during a high tide and was considered a worst-case event.

All these studies show that SPLs exceeding 120 dB RMS from vibratory pile driving range to a few miles at most because of spherical spreading and poor propagation in shallower waters

(Table 13). Using Blackwell's (2005) transmission loss model (21.8 Log (r)) with her sound level source data (164 dB re 1 μPa (rms) at 61 yd or 199.1 dB re 1 μPa (rms) at 1 yard) indicates a range of 2.65 miles to the 120 dB isopleth. The same model applied to noise source data collected by Laughlin (2010b) at Vashon (169 dB re 1 μPa (rms) at 12 yards) suggests a distance to the 120 dB threshold of 1.21 miles, whereas application of the Marsh and Schulkin (1962) model to this same data shows a distance of about 1.2 miles. Carr et al. (2006) estimated the distance to the 120 dB threshold as 0.99 mile based on the data they collected in British Columbia. Finally, Laughlin et al. (2010b) found that vibratory hammer sound levels at the Vashon ferry terminal were already attenuated to about 130 dB re 1 μPa (rms) at about 875 yards, approximating a 21 Log (r) transmission loss. Collectively, these studies strongly support that transmission loss from vibratory hammer sound levels, especially in shallow waters, is high and is best modeled using a transmission loss equation of 20 Log (r). The greatest distance estimated distance (5.11 miles) to the 120 dB isopleth (SFS, 2009) was considered a worst-case with average distances from the study closer to 1.2 miles without any mitigation measures applied.

In the previously mentioned studies, distances to the 190 dB and 180 dB injury thresholds were less than 11 yards in all cases.

Table 13. Compiled 1 Nearshore Sound Pressure Levels from Vibratory Pile Driving

Pile Type	Pile Size	SPL[2] (rms)	Radius to 120 dB Threshold (mi) without mitigation	Source
Steel Pipe	24-inch	162	0.78 [5]	Laughlin (2010a)
Steel Pipe	30-inch	170	1.49[6]	Laughlin (2010b)
Steel Pipe	36-inch	179	2.64[7]	Blackwell (2005)
Steel Pipe	36-inch	169	0.99[8]	Carr et al. (2006)
Sheet Pile	Not given	167 [3]	1.43 [5]	SFS (2009)
Steel Pile	Not given	178 [4]	5.1 [5]	SFS (2009)
Steel Pipe	36-inch	141[3]	0.07 [5]	SFS (2009)
Steel Pipe	36-inch	155 [4]	0.35 [5]	SFS (2009)

[1] Compiled from various sources
[2] Measured values were back-calculated to 11 yards values using 20 Log (r) for common comparison.
[3]Average value.
[4]Maximum value.
[5]20 Log (r).
[6]21 Log (r).
[7]21.8 Log (r).
[8]24 Log (r).

Zykov and Warner (2013) modeled pile driving sound levels relative to the proposed Chuitna port facilities near Tyonek with results greatly different than the previously mentioned studies. Zykov and Warner (2013) estimated the radii to the 120 dB threshold from various vibratory hammer scenarios to range from 16 and 17 miles for average values, and from 34 and 50 miles for maximum values (Table 14) (the modeled distance to the 180 dB isopleth for the vibratory hammer was less than 12 yards in all cases). Sound level propagation distances were least during pile driving activities modeled for the bulkhead island construction and greatest for installing the conveyor trestle and offshore dock, which occur in deeper water (where sound level propagation is greater due to less influence of the bottom-substrate). As mentioned in Section 5.1.2, Zykov and Warner (2013) modeled distances to thresholds using JASCO's MONM propagation model. If the 1-yard source SPLs in Table 14 were applied to a 20 Log (r) spherical transmission loss model, distances to the 120-dB threshold would range from approximately 2.8 to 4 miles. Although the Zykov and Warner (2013) modeling was conducted for a location very near the proposed Beluga MOF, the 6- to 11-fold difference between using MONM versus the spherical spreading model accentuates the difficulty in accurately modeling transmission loss in the far field. Actual field measurements taken at relatively far distances from the source do not support distances to threshold modeled by Zykov and Warner (2013), although all studies above suffer from not extending actual field measurements to the 120-dB isopleth (most extrapolate to the 120-dB isopleth from the farthest field measurement).

Table 14. Summary of Sound Pressure Levels (SPL) (dB re 1 μPa @ 1.09 yards) from Vibratory Pile Driving from Zykov and Warner (2013; Appendix A)

Pile Size	Power	Modeling Water Depth	SPL	Radius to 120 dB Threshold (mi)
24-30 inches	Average	11 yd	192.9	16.32
24-30 inches	Maximum	11 yd	194.1	34.08
30-36 inches	Average	12 yd	192.9	16.27
30-36 inches	Maximum	12 yd	194.1	34.39
36-48 inches	Average	13 yd	194.1	17.5
36-48 inches	Maximum	13 yd	195.5	50.29
48-60 inches	Average	26 yd	194.1	16.21
48-60 inches	Maximum	26 yd	196.7	46.7
48-60 inches[1]	Average	26 yd	194.1	16.21
48-60 inches[1]	Maximum	26 yd	195.5	45.23

[1]Fender piles

5.1.3.2 Vessel Noise

Vessels such as tugs and LNGCs generate underwater noise exceeding the non-impulsive threshold of 120 dB due largely to the continuous cavitation noise produced from the propeller arrangement of both drive propellers and thrusters. Other noise sources include onboard diesel generators and the firing rate of the main engine, but both are subordinate to the blade rate harmonics and cavitation (Gray and Greeley, 1980). Cavitation, the primary source of underwater vessel noise, is the chaotic collapse of cavities produced by the moving blades. Large ships, such as LNGCs, produce broadband 1.09-yard source levels of about 180 dB re 1 μPa (rms) (Richardson et al., 1995; Blackwell and Greene, 2002). However, because these sound levels are transient (the vessel is moving), NMFS does not consider transiting vessel sound to rise to the level of "take" (S. Guan, NMFS, pers. comm.). Thus, there is no requirement to quantify threshold-level sound exposures of marine mammals in an MMPA assessment. Some published sound levels for vessels are provided in Table 15.

Thrusters have generally smaller blade arrangements operating at higher rotations per minute (rpms) and, therefore, largely produce more cavitation noise 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 μPa (rms) at 1.09-yard source. The noise emanating from the same tug increased dramatically to 178.9 dB re 1 μPa (rms) at source (based on a measured 149 dB re 1 μPa (rms) at 109.36 yards) when the tug was using its thrusters to maneuver the barge during docking. Similarly, Laurinolli et al. (2005) estimated the underwater maximum SPLs emanating from an LNGC transiting at full speed to be 183.1 dB re 1 μPa (rms) at 1.09-yard source, but source levels increased to 192.2 dB re 1 μPa (rms) with operation of bow thrusters during the short docking period. Also, thruster onset is generally more sudden, thereby increasing the likelihood of startling (harassing) a nearby marine mammal. Marine mammal exposure to thruster noise does need to be quantified in a MMPA assessment (S. Guan, NMFS, pers. comm.).

There are three vessel noise sources of concern associated with the Project:

- Thrusters when docking barges and LNG carriers;

- Thrusters on anchor handling tugs (AHTs) during anchor relocation; and
- General cable-winching and other sources on the laybarge.

For the tug during docking maneuvers (Blackwell and Greene, 2003), the estimated distance to the 120-dB threshold at about 2.7 miles based on their calculated transmission loss of 17.8 Log (r) and a measured source of 149 dB re 1 µPa (rms) at 112 yards, but only 1.27 miles when applying the same model to the back-calculated source value of 178.9 dB re 1 µPa (rms). Applying a 20 Log (r) transmission loss model to Laurinolli et al.'s (2005) source of 192.2 dB re 1 µPa (rms) results in a radius to the 120-dB threshold of 2.53 miles for the docking LNG carrier, but only 5.5 yards to the 180-dB Level A threshold. These values are similar to the measured distances of 1.9 to 3 miles to the 120 dB isopleth from sound radiating from bow thrusters operating from a rig tender (McCauley, 1998) and an icebreaker (Greene, 1987; Brueggeman et al., 1990). However, Laurinolli et al. (2005) used JASCO's conservative MONM model to estimate the distances to the 120-dB threshold from the docking LNGC and presented radii of 8.7 to 13.7 miles, depending on scenario (dock location, water depth, depth of hydrophone).

Underwater noise levels associated with offshore pipelay operations include general sounds from the pipelay barge that includes winching of anchor cables, and thruster noise from the AHTs during anchor pulling. Laurinolli et al. (2005) measured noise levels from a large semi-submersible pipelay barge (*Semac 1*) held on station with a 12-anchor spread, similar to that planned for the Project. They estimated the broadband source value at 179.3 dB re 1 µPa (rms), and modeled (using MONM) the distance to the 120-dB isopleth to 4.4 miles. If the spherical spreading model (20 Log (r)) were applied to the source value, the distance would be about 1,009 yards.

Laurinolli et al. (2005) also measured bow thruster sound levels from AHTs during anchor pulling operations associated with the pipelay barge and found a broadband source of 199.7 dB re 1 µPa (rms) for the 49-yard *Britoil 51* and 181.6 dB re 1 µPa (rms) for the larger 73.9 yards *Katun*. The estimated distance to the 120-dB isopleth is 6 miles and 0.75 mile, respectively, using the spherical spreading model. The average broadband source level is 190.7 dB re 1 µPa (rms) equating to a distance to threshold of 2.13 miles. Laurinolli et al. (2005) did not provide radial distance estimates specific to tugs during anchor pulling operations. Austin et al. (2013) also measured anchor handling sound from the *Tor Viking II* operating in the Beaufort Sea and estimated the distance to the 120-dB isopleth at 7.46 miles using the spherical spreading model and 15 miles using the practical spreading model. No source value was given, but it would have been approximately 201.6 dB re 1 µPa (rms) based on the radii values relative to sound levels provided. LGL, JASCO, Greeneridge (2014) also measured the Tor Viking II during anchor handling in the Chukchi Sea and found source levels were higher (207.4 dB re 1 µPa (rms)) but the transmission loss was greater (21.1 Log (r)) with an estimated distance of 8.7 miles to the 120-dB threshold.

Table 15. Representative Underwater Sound Levels from Proposed Vessel Activity

Vessel Type	SPL [1]	Distance to 120 dB Threshold [2] without mitigation	Source
Pipelay Barge	179.3 dB	1,009 yd	Laurinolli et al. (2005)
Tug (anchor pulling)	199.7 dB	6 mi	Laurinolli et al. (2005)
Tug (anchor pulling)	181.6 dB	0.81 mi	Laurinolli et al. (2005)
Tug (anchor pulling)	201.6 dB	7.52 mi	Austin et al. (2013)
Tug (anchor pulling)	207.4 dB	8.7 mi	LGL, JASCO, Greeneridge (2014)
Tug	163 dB	155 yd	Carr et al. (2006)
Tug	161 dB	124 yd	Patterson et al. (2007)

Vessel Type	SPL [1]	Distance to 120 dB Threshold [2] without mitigation	Source
Tug and Barge (transiting)	164 dB	0.78 mi	Blackwell and Greene (2005)
Tug and Barge (docking)	179 dB	2.64 mi	Blackwell and Greene (2005)
Tug and Barge	182 dB	0.78 mi	Zykov and Hannay (2006)
Self-propelled barge unloaded	163 dB	155 yd	Zykov and Hannay (2006)
Self-propelled barge full load	174 dB	549 yd	Zykov and Hannay (2006)
Flat bottom workboat full speed	163 dB	155 yd	Galli et al. (2003)
LNG Carrier half speed	164 dB	174 yd	Carr et al. (2006)
LNG Carrier full speed	184 dB	0.99 mi	Arveson and Vendittis (2000)
LNG Carrier docking (DP mode)	192 dB	2.48 mi	Laurinolli et al. (2005)

[1]Sound pressure levels re 1 μPa (rms) at 1 meter (1.09 yard)
[2]20 Log (r)

5.1.4 Other Underwater Sound Sources

Other underwater sound sources expected during the construction phase of the Project include sound associated with dredging and trenching. None of the sound sources associated with these activities are impulsive, but some of the sources, such as backhoeing and dumping, are also not continuous. Representative sound levels and distances to the 120 dB threshold are found in Table 16. All of the sound sources exceed threshold at distances less than 219 yards. URS (2007) also measured underwater sound levels associated with U.S. Army Corps of Engineers (USACE) dredging activities at Anchorage. They found sound levels to range between 136 and 141 dB re 1 μPa (rms) at distances ranging between 13 and 21 yards from the source. Assuming a maximum 141 dB received level at 13 yards, the distance to the 120 dB isopleth would be about 148 yards when applying the spherical spreading model of 20 Log (r). Dredge sound from this study would not have exceeded 190 and 180 dB at the source.

Table 16. Representative Underwater Sound Levels from Other Proposed Activities

Activity	Sources	SPL Documented	SPL Ref. to 11 yd	Distance to Threshold	Source
Dredging	Clamshell dredge of mixed coarse sand/gravel	113 dB @ 164 m	136.5 dB	74.4 yd	Dickerson et al. (2001)
	Clamshell dredge in soft sediments	107 dB @ 11 yd	107 dB	3.3yd	Dickerson et al. (2001)
	Wincing in/out10	117 dB @ 164 yd	140.5 dB	117 yd	Dickerson et al. (2001)
	Dumping into barge	109 dB @ 164 yd	132.5 dB	47 yd	Dickerson et al. (2001)
	Empty barge at placement site	109 dB @ 345.6 yd	139 dB	98.4 yd	Dickerson et al. (2001)
	Clamshell dredge at the POA	141 dB @ 13.1 yd	142.6 dB	147.6 yd	URS (2007)
Underwater trenching	With backhoe in shallow water	125 dB @ 109 yd	145 dB	194.6 yd	Greene et al. (2007)
Underwater grading	With dozer in shallow water	114 dB @ 109 yd	134 dB	55.7 yd	Greene et al. (2007)

5.1.5 Underwater Sound Relevant to Marine Mammals

Based on NMFS's interim guidelines, Level B harassment of marine mammals occurs when anthropogenic underwater noise levels exceed 160 dB re 1 µPa (rms) for impulsive noise sources and 120 dB re 1 µPa (rms) for non-impulsive sources. Estimating the radius to these distances can be modeled in multiple ways. Based on the reference material cited herein, the expected transmission loss rate in Cook Inlet waters follows somewhere between about 17.5 Log (r) and 22 Log (r), averaging about 20 Log (r) (spherical spreading). Based on this range of spreading models, the most significant noise sources in descending order are anchor pulling, vibratory driving of round pile, LNGC thruster noise while docking, and impact driving of round pile. Both anchor pulling and vibratory pile driving exceed 199 dB re 1 µPa (rms) at 1.1-yard source (Table 17: Blackwell, 2005; Laurinolli et al., 2005). Distances to the threshold isopleths range from about 109 yards (impact hammering of sheet pile) to about 6.2 miles (anchor pulling).

In a Project meeting on 15 September 2016, NMFS recommended that distances to thresholds be modeled for incidental take authorizations using the 15 Log (r) practical spreading model. This is very conservative model that is used when there is no transmission loss data available for the activity proposed in the waterbody where it will occur. NMFS may require this model be used to establish initial shutdown and monitoring zones until sound level source verification studies are conducted to verify actual zones. NMFS may also require that marine mammal exposure estimates be recalculated using the practical spreading model to redefine zones of influence (ZOIs), although evidence suggests this model in inappropriate. As can be seen in Table 17, use of this model would expand the modeled radii nearly a magnitude versus the using the spherical spreading model.

Table 17. Representative SPLs and Radial Distances to NMFS Thresholds for the Primary Underwater Noise Producing Activities during Construction and Operation of the Project

Activity	SPL (dB re 1 µPa (rms))	Source	Radius to Level B Threshold[1] without mitigation			
			21.8 Log (r)[2]	20 Log (r)[3]	17.5 Log (r)[2]	15 Log (r)[4]
Impact Pile Driving (Pipe)	222 dB @ 1.1 yd	Blackwell (2005)	-	.8 mi	2.2 mi	8.5 mi
Impact Pile Driving (Sheet)	199.7 dB @ 1.1 yd	SFS (2009)	-	106 yd	202.3 yd	485.5 yd
Impact Pile Driving (H-pile)	160 dB @ 328.1 yd	URS (2007)	-	328.1 yd	328.1 yd	328.1 yd
Vibratory Pile Driving (Pipe)	199.1 dB @ 1.1 yd	Blackwell (2005)	2.6 mi	5.6 mi	-	116.8 mi
Vibratory Pile Driving (Sheet)	187 dB @ 1.1 yd	SFS (2009)	0.7 mi	1.4 mi	-	18.2 mi
Tug and Barge (Docking)	178.9 dB @ 1.1 yd	Blackwell and Greene (2003)	-	964.6 yd	-	5.3 mi
LNGC (Docking)	192.2 dB @ 1.1 yd	Laurinolli et al. (2005)	-	2.5 mi	-	40.5 mi
Pipelay Barge	179.2 dB @ 1.1 yd	Laurinolli et al. (2005)	-	998.5 yd	-	5.5 mi
AHT (Anchor Pulling)	194.3 dB @ 1.1 yd	Laurinolli et al. (2005)	-	3.2 mi	-	55.9 mi
Dredging	141 dB @ 13.1 yd	URS (2007)	-	147.6 yd	-	330.3 yd

[1]160 dB for impulsive sound and 120 dB for non-impulsive (continuous)
[2]Blackwell (2005)
[3]Spherical spreading model
[4]Practical spreading model
[5]Average of 199.7 dB, 181.6 dB, and 201.6 dB

While the effect of modeling with the practical spreading model has significant implications in regard to receipt of an LOA and the cost of monitoring for marine mammals, it should be noted that for nearly all activities in Table 17, the majority of the sound energy is found in frequencies less than 1 kilohertz (Miles et al., 1987; Richardson et al., 1995; Simmonds et al., 2004; Laurinolli et al., 2005) and peak energies less than 100 hertz (Areveson and Vendittis, 2000; Laurinolli et al., 2005; McKenna et al., 2012). Frequencies above 1 to 2 kilohertz do not propagate well in shallower waters (Blackwell and Greene, 2003). For example, Laurinolli et al. (2005) found that while the broadband source level was 179.2 dB re 1 μPa (rms), the highest narrow band SPL was 166.3 dB re 1 μPa (rms) at 80 hertz and only 145.6 dB re 1 μPa (rms) at 2 kilohertz. Similarly, the loudest anchor pulling noise was recorded by Laurinolli et al. (2005) as 199.7 dB re 1 μPa (rms) broadband, and a maximum narrow band of 196.7 dB re 1 μPa (rms) at 25 hertz. At 2 kilohertz, the SPL was only 166.5 dB re 1 μPa (rms), which equates to 0.78 miles to the 120-dB isopleth using even the conservative practical spreading model (and only 231 yards using the spherical spreading model).

Auditory thresholds for beluga whales have been described at between 2 and 130 kilohertz (Finneran et al., 2005), with maximum sensitivity between 10 and 70 kilohertz (Wartzok and Ketten, 1999). Kastelein et al. (2002) measured the hearing range of the harbor porpoise and reported the full hearing range to be 0.25 to 180 kilohertz, the most sensitive range 16 to 140 kilohertz, and the maximum sensitivity hearing range to be 100 to 140 kilohertz. Harbor seals and killer whales have maximum hearing sensitivity in the 10 to 30 kilohertz range (Wartzok and Ketten, 1999). Collectively, the marine mammals most likely to be encountered in mid and upper Cook Inlet have poor hearing at the dominant frequencies of pile driving hammers and vessel thrusters.

5.1.6 Ambient Underwater Sound

Hannay (2011) measured the ambient underwater sound levels in 11 yard and 30 yard water depths just offshore of Ladd Landing (near the proposed Beluga MOF). Broadband ambient levels ranged between 96 and 102 dB re 1 µPa in the shallower depth and between 108 and 109 dB re 1 µPa in the deeper depth, with most energy occurring below 1 kilohertz. Higher ambient sound levels have been reported in upper Cook Inlet (Blackwell and Greene, 2002; Blackwell, 2005; URS, 2007; Scientific Fishery System, 2009), but these levels were associated with bore tides near Knik Arm and Turnagain Arm, or industrial sound associated with the Port of Anchorage. Ambient underwater sound levels are expected to remain below 120 dB at all proposed construction locations (except during storm conditions).

5.1.7 Airborne Sound

Loud airborne sounds can disturb any marine mammal with its ear canal exposed above water, but hauled out pinnipeds appear to be especially sensitive to this kind of disturbance. In the case of walrus, disturbance can often lead to stampeding back into the water with some individuals injured or killed in the crush. There are no airborne sound level criteria for cetaceans, sea otters, or polar bears, but disturbance thresholds have been established for pinnipeds (Table 10). NMFS has established that Level B harassment to harbor seals may occur when the animals are exposed to airborne sound level exceeding 90 dB rms (unweighted). For all other pinnipeds, the threshold is 100 dB rms (unweighted).

Several proposed activities would produce significant airborne noise (Table 18), of which impact pile driving is the loudest noise source, and the only one that would exceed NMFS thresholds and actually occur over marine waters. Airborne noise levels, at source, from impact hammering are a function of the size and impact energy of the pile driver, dimension of the pile, and properties of the seafloor (MacGillivray et al., 2011; Van Renterghem et al., 2014). Noise in air generally spreads spherically, following the inverse square law, with a transmission loss of approximately 20 Log (r). Overwater transmission loss can be increased with wind and associated wave actions, thereby reducing the size of area ensonified by sound pressure levels exceeding thresholds (Van Renterghem et al., 2014).

Measured and modeled distances to the 90 dBA threshold have generally ranged from a few yards to a few hundred yards depending on pile type. During impact driving of a 72-inch pinpile, Van Renterghem et al. (2014) predicted that while maximum sound pressure levels would still be audible up to 6.2 miles, sound levels would attenuate to below 90 dBA at about 219 yards. Illingworth and Rodkin (2015a) measured impact driving of a 36-inch concrete pile and found maximum sound levels at 16 yards to be 109 dBA, equating to a distance of only 149 yards to the 90 dBA threshold (applying the 20 Log (r) spherical model). In contrast, Laughlin (2005b) measured airborne sound levels from impact pile driving a 24-inch steel pile at 112 dB (rms) at 54 yards from the pile, suggesting a radius to the 90 dBA threshold of about 711 yards.

Laughlin (2010b) measured airborne noise associated with a vibratory driving of a 30-inch pile and found an average unweighted value at 16 yards of 97.8 dB and maximum values as high as 105 dB, equating to maximum distance to the 90 dB threshold of 86 yards. Illingworth and Rodkin (2015a) measured airborne sound levels from vibratory driving a 36-inch steel shell pile found average sound levels as high as 100 dBA and maximum levels to 108 dBA at 16 yards, representing a radius of approximately 137 yards to the 90 dBA threshold.

Based on the data, airborne sound levels exceeding threshold values from impact and vibratory pile driving is not expected to exceed 0.5 mile, regardless of hammer type or pile size.

All pile driving (and all airborne sound sources exceeding 90 dB) would occur in either Cook Inlet or Prudhoe Bay; thus, only harbor seals (Cook Inlet) and spotted seals (Prudhoe Bay) are potentially affected, unless pile driving at West Dock would occur in the winter, in which ringed seals hauled on ice might be affected. The nearest known haul out sites for either harbor or spotted seals to proposed pile driving operations range between 6.2 and 12.4 miles, or at distances well beyond the range where sound levels would attenuate to below threshold levels. According to Montgomery et al. (2007), the nearest harbor seal haul out site to the proposed Marine Facility is located at the mouth of the Kenai River, approximately 9 miles south of Nikiski. Proposed pile driving activity on the western shore Cook Inlet would occur 6 miles or greater south of the mouth of the Beluga River where harbor seals seasonally haul out. West Dock, Prudhoe Bay, is located 12 miles west the mouth of the Sagavanirktok River, where spotted seals traditionally hauled out (Johnson et al., 1999). Certainly, any swimming pinniped surfacing within the airborne ZOI of an active hammer would be exposed to harassment-level airborne noise, but these animals would already be accounted for in any estimate of exposure from underwater noise. All proposed activity producing significant airborne noise (including from dredging) would occur outside the normal range of sea otters, and any polar bear exposure would already constitute a bear-human safety issue.

As pile driving is planned to occur at West Dock during the winter, there is the potential to disturb hauled out ringed seals or pups in lairs. Frost et al. (2004) found winter ringed seal densities in the Beaufort Sea to be highest in water depths between 5.5 and 16.4 yards, and for waters less than 3.2 yards deep, sea ice is expected to extend to the sea bottom (bottom-fast ice). The distance from proposed West Dock expansion site to the 3.2- and 5.5- yards isobaths is 1.03 and 2.2 miles, respectively, or well beyond the 86 to 711 yards airborne sound levels expected to exceed 90 dBA, based on the previously mentioned studies.

Because none of the pinniped haul out sites in Cook Inlet or Prudhoe Bay occur within the areas that the proposed construction activities ensonify 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.

Some ringed seals in Prudhoe Bay and harbor seals in Cook Inlet could potentially be disturbed by airborne sounds associated with the project; however, based on the above analysis, any such effects would be minor and temporary.

Table 18. Representative Airborne Noise Levels from Proposed Marine Construction Activities

Activity	Sources	Airborne sound levels (Published unweighted rms)	Airborne Sound Levels (Referenced to 10 m)	Reference	Exceeds Criterion [2]
Cutting/Paving/ Grading	Dozer, Excavator, Grader, Paver, Scraper	85 dB @ 16.4 yd	89 dB	CNH[1]	No
Dredging	Operation of dredging barge	77 dB @ 16.4 yd	81 dB	Epsilon Assoc. (2006)	No
Pile driving	Tubular – vibratory	91 dB @ 16.4 yd	95 dB	Laughlin (2010)	Yes
	Sheet – vibratory	83 dBA @ 38.3 yd	94 dBA	Illingworth & Rodkin (2013)	Yes
	Tubular – vibratory 18” pile	88 dB @ 16.4 yd	92 dB	Laughlin (2010)	Yes
	Tubular – vibratory 30” pile	98 dB @ 16.4 yd	102 dB	Laughlin (2010)	Yes
	Tubular – impact 72” pile	102 dB @ 16.4 yd	106 dB	Laughlin (2011)	Yes
	Tubular – impact 36” pile	109 dBA @ 16.4 yd	113 dBA	I&R (2015)	Yes
	Tubular – impact 48” pile	104 dBA @ 16.4 yd	108 dBA	I&R (2015)	Yes

Activity	Sources	Airborne sound levels (Published unweighted rms)	Airborne Sound Levels (Referenced to 10 m)	Reference	Exceeds Criterion [2]
Onshore Vehicles	35-ton hauler loaded	86 dB @ 16.4 yd	90 dB	Epsilon Assoc. (2006)	No
	200-ton unloading crane	88 dB @ 16.4 yd	92 dB	Epsilon Assoc. (2006)	No
Support	Concrete Mixing	101 dB @ 16.4 yd	105 dB	CNH[1]	Yes
	Front end loader	79 dB @ 16.4 yd	83 dB	CNH[1]	No
	Portable Generator	81 dB @ 16.4 yd	85 dB	CNH[1]	No
	Welding	74 dB @ 16.4 yd	78 dB	CNH[1]	No

[1]Construction Noise Handbook
[2]The published airborne sound levels or the airborne sound levels referenced to 10 meters exceeds the NMFS airborne criteria in Table 10 (90 dB, 100 dB unweighted)

5.1.8 Aircraft Overflight Noise

Noise associated with aircraft traffic to and from construction sites could cause behavioral disturbances to marine mammals where the flight occurs over marine waters, such as crossing Cook Inlet. Behavioral effects on baleen whales from aircraft overflights are typically ephemeral consisting of hasty dives, direction changes, or changes in respiration rates (Richardson et al., 1995). Reactions to aircraft overflights are sometimes conspicuous at an altitude of 1,000 feet but are considered uncommon at altitudes of 1,500 feet or more (BOEM, 2016; Richardson et al., 1995). For incidental take authorizations, NMFS generally applies a minimum altitude of 1,500 feet to overflights to avoid or minimize such impacts. Project flights over marine waters would be limited to altitudes of 1,500 feet or greater above ground level, thereby eliminating any disturbance concerns.

Toothed whales such as belugas have also shown varied responses to aircraft overflights, but reactions again consist or hasty or longer dives (Richardson et al. 1995). Reactions have rarey been observed with regards to overflights at altitudes in excess of 1,500 feet,

Pinniped reactions to aircraft have not been well studied but anecdotal reports vary. In the water pinnipeds may become more alert or dive. Effects of overflights can be more serious at haulouts and rookeries for such species as Pacific walrus, Steller sea lion, and fur seal, with potential mortalities from trampling or loss of contact. Low altitude flights over pupping beaches have also been implicated in mortalities of harbor seals (Johnson, 1977). There are no known pinniped rookeries or haulouts within 9 miles of the Project footprint, so Project flights would not be expected to impact rookeries or haulouts.

5.2 DREDGING

Dredging and seabed preparation at the Marine Terminal would be completed during April through October during the first construction season using a dredging barge (barge-mounted crane, clamshell) and hydraulic dredge operating for approximately 206 days. Dredging of the temporary MOF would be the most extensive excavation with an estimated 34-acre footprint ranging from -5 to -32 feet MLLW. Substrates within these proposed dredge areas are primarily medium dense sandy silt and sand overlying hard sandy clay. Cobbles and boulders of varying sizes are also present. Seabed preparation would be completed by backfilling the dredged area with gravel and rock. Because of the high natural turbidity in Upper Cook Inlet, it is unlikely that dredging and dredge disposal would exceed background water turbidity more than 200 feet from these activities. Maintenance dredging may be required in subsequent years to maintain channel depths depending on the rate of sedimentation.

5.3 VESSEL STRIKE

During operation of the Liquefaction Facility, Project LNGCs would visit the Marine Terminal at an expected rate of about 21 visits per month. This LNGC traffic would likely result in a long term increase in the traffic of large vessels in Cook Inlet. An analysis of probable increases in the incidence of vessel – whale collisions due to the increased ship traffic was conducted; the methods and results of the analysis are provided in Attachment 1. Two areas were looked at: 1) Cook Inlet and adjacent Gulf of Alaska, and 2) North Pacific Great Circle and southern routes in the Gulf of Alaska and Bering Sea near the Aleutian Islands.

The results of the analysis indicate that the LNGCs may increase large vessel traffic in Cook Inlet by 50 percent, and traffic in the Great Circle area by about 9 percent. The estimated increase in the number of whale strikes per year due to the increase in vessel traffic from Project LNGCs would be negligible ranging from 0.065 strikes per year for the North Pacific Great Circle and southern routes to 0.137 strikes per year for Cook Inlet routes. Based on these projected increases in whale strike rates, LNGC traffic over the 30-year life of the Project could potentially result in mortality of one Cook Inlet beluga whale; two large baleen whales, which could include blue, fin, or sei whales; and three humpback whales. Based on the available ship strike records, no other species of whales or pinnipeds are likely to be injured or killed by collisions with LNGCs.

Collisions with marine vessels have been implicated in the deaths of marine mammals (Goldstein et al., 1999; Laist et al., 2001; Jensen and Silber, 2004; Panigada et al,. 2006; Van Waerebeek et al., 2007; Berman-Kowalewski et al., 2010). Whale mortality from ship strike is usually a result of blunt force injury from striking the ship bow (blunt trauma), or lethal wounding from propeller cuts (sharp trauma) (Moore et al., 2013). Worldwide (Laist et al., 2001; Jensen and Silber, 2004) and off Washington (Douglas et al., 2008), fin whales are the most common cetacean killed by vessels. This may be a function of a greater population size or higher density in shipping lanes as opposed to a greater biological vulnerability (Douglas et al., 2008). Douglas et al. (2008) also noted that fin whales were more susceptible to blunt trauma from a bow strike, while gray whales were more likely to be injured by sharp trauma from a propeller strike. Neilson et al. (2012) documented 108 ship strikes resulting in 25 known mortalities in Alaska from 1978 to 2011 and found the vast majority involved humpback whales in Southeast Alaska. Helker et al. (2016) reported 23 vessel strikes in Alaska that resulted in a mortality, serious injury, or were prorated to reflect the likelihood of a serious injury during 2010 to 2014. All of these records indicate that baleen whales are more susceptible to vessel strike than toothed whales.

Vessel speed is the primary factor in the probability of a vessel strike occurring, as well as the probability of the strike actually being lethal (Jensen and Silber, 2004; Vanderlaan and Taggart, 2007). The large whale ship strike database (Jensen and Silber, 2004) indicates that the number of vessel strikes by vessels traveling at less than 11.5 miles per hour (10 knots) is very low relative to the number of vessels normally traveling at those speeds. Vanderlaan and Taggart (2007) analyzed the ship strike database (Jensen and Silber, 2004) and found that the probability of a strike being lethal (as opposed to survivable) was also low (less than 20 percent) for strikes at speeds less than 9.3 miles per hour (8 knots), but high (greater than 50 percent) at speeds greater than 13.7 miles per hour (12 knots).

The relationship between vessel speed and the probability of a whale ship strike and other information were used to develop the 10-knot restriction now enforced in North Atlantic right whale (NMFS, 2008) habitat off New England. Conn and Silber (2013) estimated that implementation of this vessel speed rule reduced the risk of vessel collisions with right whales by 80 to 90 percent. A study to determine the effectiveness of the Ship Strike Rule and Seasonal Management Areas (SMAs) for the North Atlantic right whale found that while overall, lethal vessel strikes appeared to be less common than before the regulations were implemented, the SMAs were ineffective in reducing ship strike mortality during managed times (van der Hoop et al., 2015). Inability to detect the intended effects of the Ship Strike Rule were attributed to (1) low vessel compliance with SMAs; (2) insufficient time and/or monitoring to evaluate rule effectiveness; and (3) SMAs may be too small, in the wrong locations, or in effect for too short of duration (van der Hoop et al., 2015).

Small cetaceans appear to be less susceptible to ship strikes. No dolphin or porpoise ship strikes were documented during 2010 to 2014 (Helker et al., 2016). One possible ship strike of a Cook Inlet beluga whale and one ship strike of a killer whale have been documented in Alaska (Neilson et al., 2012; Helker et al., 2016). Both appeared to be sharp trauma from a propeller strike. Because the killer whale ship strike involved a fishery vessel, and the killer whale was likely attracted to the actively fishing vessel, it is not included in this analysis of potential Liquid Natural Gas Carrier (LNGC) whale strikes. This 2010 killer whale ship strike record was similarly not included in the Neilson et al. (2012) ship strike analysis.

Pinnipeds are far less susceptible to vessel strikes than cetaceans, probably because of their visual awareness both above and below water, and their quick maneuverability. Of 6,197 strandings of six species of pinnipeds in central California between 1986 and 1998, only five exhibited vessel strike damage. No ship strike mortality or serious injuries were reported for pinnipeds in Alaska during 2010 to 2014, although records do include one serious injury to a harbor seal by a NOAA Law Enforcement vessel traveling at 35 knots in Southeast Alaska in 2012 (Helker et al., 2016).

1.1.1 **Method**

The relationship between current levels of vessel traffic and reported whale strikes provides a baseline for predicting increases in whale strikes from increases in vessel traffic. The probability of a whale strike can be stated in terms of strikes per port calls or vessel transits. LNGCs traveling to and from the Marine Terminal at Nikiski would represent new and additional ship traffic within Cook Inlet and across the North Pacific. The method used in estimating whale strikes for Project-related LNGC traffic is that the likelihood of an LNGC striking a whale is proportional to the current estimated level of vessel traffic and the estimated annual rate of whale strikes within the routes traveled during 2000 to 2014.

Data reviewed and used for the estimate included:

- Port calls in Cook Inlet in 2010 (Cape International, Inc., 2012);
- Vessel traffic through the Aleutian Islands – Great Circle Route and southern route in 2012 (Nuka, 2015);
- LNGC routes and projected frequency; and
- NMFS records of ship strikes in Alaska (Neilson et al., 2012; Helker et al., 2016).

The anticipated risk of ship strikes resulting from increased vessel traffic due to Project LNGC port calls in Cook Inlet and transits through the North Pacific Great Circle or southern routes were projected based on the 2000 to 2014 rate of whale ship strikes for these areas. Shelikof Strait was included with Cook Inlet for projections.

5.3.1 Existing Vessel Traffic

5.3.1.1 Cook Inlet

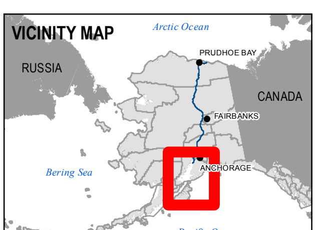
There were 480 calls to Cook Inlet ports by vessels greater than 300 Goss Tons (GT) in 2010 (Table 19). This included the *Polar Spirit*, which was the sole LNGC to call at the existing Kenai LNG Plant at Nikiski that year with a total of 16 port calls. No published studies have quantitatively summarized vessel traffic through Shelikof Strait, although many of the commercial vessels, cruise ships, tugs with barges, and ferries that operate in Cook Inlet also transit Shelikof Strait.

Table 19. Port Calls in Cook Inlet in 2010 for Vessels Greater than 300 Gross Tons

Vessel Type	Number of Calls	Percent of Calls
Cargo/General	35	7.1%
Cargo/Container	109	22.2%
Cargo/ Roll-on/Roll-off (RORO)	109	22.2%
Cruise ship	12	2.4%
Ferry	114	23.3%
LNGC	16	3.3%
Tank Ship	95	19.4%
Grand Total	490	100%

Source: Cape International, Inc., 2012

Figure 6 shows proposed LNGC routes through Cook Inlet and Shelikof Strait. Most deep-draft vessels transit north-south along the east side of Cook Inlet, while tank ships occasionally transit east/west between Nikiski and the Drift River terminal on the western side of middle Cook Inlet.



LEGEND

- Deep Draft Port (>20,000 Gross Tons)
- Light Draft Port (<20,000 Gross Tons)
- Alaska Place Names
- Project Facility
- Alaska LNG Rev C2 Route
- Proposed LNGC Route
- Major Highways
- Major Rivers

0 10 20 40 Nautical Miles

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PROPOSED LNGC ROUTE SEGMENTS

FIGURE 6

ALASKA LNG

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5.3.1.2 North Pacific Great Circle and Southern Routes

Vessels of 300 gross tons or larger transiting the Aleutian Islands are typically moving commercial goods and raw materials along the North Pacific Great Circle Route between western North America and East Asia (Nuka, 2015). Depending on conditions, vessels may stay entirely to the south of the Islands or they may pass through the Aleutian Island chain through Unimak Pass or another pass. Vessels that remain south of the islands often pass very close to shore. Monitoring data for Automated Identification System (AIS) signals from passing ships recorded 4,615 transits through Unimak Pass in 2012 (Nuka, 2015). Vessels that skirted the island chain to the south were not completely captured via AIS signals, although 1,023 transits were recorded shown in Figure 7 (Nuka, 2015).

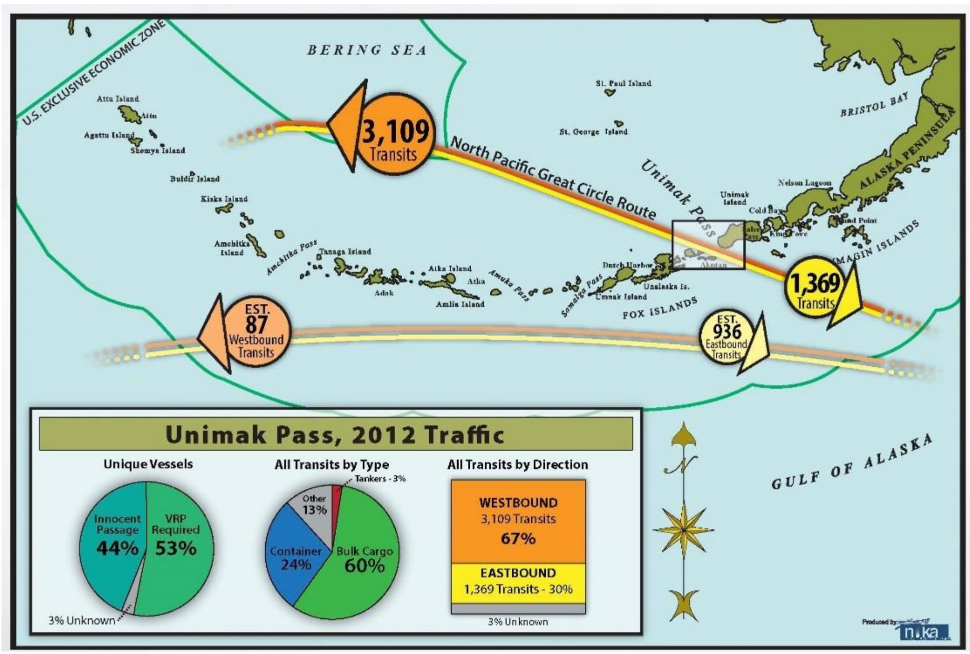


Figure 7: Idealized Routes with Summary of 2012 Vessel Transits (Nuka, 2015)

5.3.1.3 Project LNGCs

Loading berths at the Marine Terminal would be designed for a range of LNGC sizes to accommodate specific marketing requirements. Based on a nominal 176,000 cubic meters LNGC design vessel, approximately 21 vessel calls per month or 252 calls per year and 504 transits across the North Pacific would be required to export the produced LNG. The LNGCs would range in size between 125,000 cubic meters (approximately 30 vessel visits per month) and 216,000 cubic meters (approximately 17 vessel visits per month). LNGCs sail at average speeds of 19 to 19.5 knots. Project LNGC traffic would increase Cook Inlet large vessel port calls by 52.5 percent and transits through the North Pacific Great Circle and southern routes by 8.9 percent.

5.3.2 Marine Mammal Ship Strike Estimates

Neilson et al. (2012) documented 108 ship strikes resulting in 25 whale mortalities in Alaska from 1978 to 2011 and found the vast majority to involved humpback whales in southeast Alaska. After review, these records were narrowed to the collisions that likely resulted in severe injury or mortality and occurred within or near projected LNGC routes. Collisions that may have occurred in Gulf of Alaska waters and transported the whale to interior ports were included. Helker et al. (2016) was reviewed for collision records within the areas of interest during 2012 to 2014. A total of 18 documented and probable ship strike records resulting in death or serious injury were identified for Cook Inlet, and North Pacific Great Circle and southern routes (Attachment 1). These records were used to generate annual ship strike estimates for LNGC routes through Cook Inlet and the North Pacific Great Circle Route and southern routes.

All ship strike records identified within the LNGC routes were for large whales, with the exception of a single beluga whale record. No lethal or injurious ship strikes of sperm whales have been documented in Alaskan waters (Neilson et al., 2012; Helker et al., 2016). Average annual ship strikes were 0.11 whales for Cook Inlet and 0.38 whales for the North Pacific Great Circle Route during the 37 year period from 1978 to 2014. Average annual ship strikes were 0.27 whales for Cook Inlet and 0.73 whales for the North Pacific Great Circle Route during the 15 year period from 2000 to 2014 (Table 20). The increase in average annual ship strikes between these two periods may be due to an increase in ship strikes or from more comprehensive reporting; although with many whale populations increasing and the likely increase in shipping traffic it is possible that there has been a real increase in ship strikes in these regions (Table 21). The ship strike records for the 15 year period from 2000 to 2014 are considered to be most representative of current ship strike and shipping traffic levels and were carried forward in this assessment. Whale ship strikes in Cook Inlet occurred during spring and fall, while ship strikes in the North Pacific occurred from March through September, with the peak in July (Figure 8).

Table 20. Estimated Annual Increase in Whale Strikes due to Increased Vessel Traffic

Species	Documented Strikes[1]		Strikes per Year		Increase in Traffic		Increase in Strikes per Year	
	Cook Inlet	Great Circle	Cook Inlet	Great Circle	Cook Inlet	Great Circle	Cook Inlet	Great Circle
Beluga Whale, Cook Inlet	1	0	0.067	0	52.5%	8.9%	0.035	0
Cuvier's Beaked Whale	0	1	0	0.067	52.5%	8.9%	0	0.006
Fin Whale	0	3	0	0.200	52.5%	8.9%	0	0.018
Large Baleen Whale[2]	1	2	0.067	0.133	52.5%	8.9%	0.035	0.012
Humpback Whale	2	4	0.133	0.267	52.5%	8.9%	0.070	0.024
Unidentified Whale	0	1	0	0.067	52.5%	8.9%	0	0.006
All Whales	4	11	0.267	0.733	52.5%	8.9%	0.140	0.065

Sources: Neilson et al., 2012; Nuka, 2015; Helker et al., 2016

[1] Based on 15 records from 2000 to 2014 identified as ship strikes with serious injury or mortality located within Cook Inlet and Shelikof Strait (Cook Inlet); or Gulf of Alaska and Aleutian Island region along the North Pacific Great Circle Route and southern route (Great Circle).

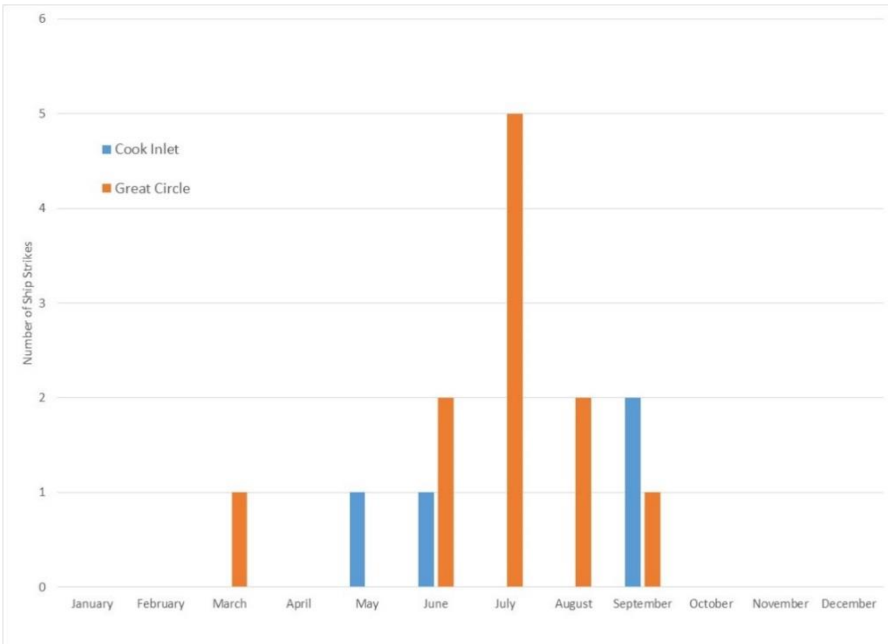
[2] unidentified appeared to be a fin, blue or sei whale

Table 21. Projected Whale Strikes due to Increased Vessel Traffic over the 30-Year Project Life

Species	Increase in Strikes per Year		Projected Strikes (30 years)		
	Cook Inlet	Great Circle	Cook Inlet	Great Circle	Total
Beluga Whale, Cook Inlet	0.035	0	1.05	0	1.05
Cuvier's Beaked Whale	0	0.006	0	0.18	0.18
Fin Whale	0	0.018	0	0.53	0.53
Large Baleen Whale[2]	0.035	0.012	1.05	0.36	1.41
Humpback Whale	0.070	0.024	2.10	0.71	2.81

Unidentified Whale	0	0.006	0	0.18	0.18
All Whales	0.140	0.065	4.20	1.96	6.16

Sources: Neilson et al., 2012; Nuka, 2015; Helker et al., 2016
[1] Based on 15 records from 2000 to 2014 identified as ship strikes with serious injury or mortality located within Cook Inlet and Shelikof Strait (Cook Inlet); or Gulf of Alaska and Aleutian Island region along the North Pacific Great Circle Route and southern route (Great Circle).
[2] unidentified appeared to be a fin, blue or sei whale



Source: Neilson et al., 2012; Helker et al., 2016

Figure 8: Whale Ship Strikes by Month in Cook Inlet and the North Pacific Great Circle Route

1.1.2 Conclusion

The annual rate of increase in whale strikes from LNGC traffic would be immeasurable ranging from 0.065 for the North Pacific Great Circle and southern routes to 0.140 for Cook Inlet routes. Based on these projected increases in whale strike rates, the increase in vessel traffic from Project LNGCs over the 30-year life of the Project could potentially result in mortality of 1 Cook Inlet beluga whale; 2 large baleen whales which could including blue, fin, or sei whales; and 3 humpback whales. Based on the available ship strike records, no other species of whales or pinnipeds are likely to be injured or killed by vessel collisions. Mitigation measures to be implemented to minimize the potential for whale strikes by the LNGCs include a marine mammal monitoring program.

Because the Cook Inlet beluga whale has not increased due to unknown reasons, NMFS does not calculate the Potential Biological Removal (PBR) for this stock (Allen and Angliss, 2015). Because an estimated minimum abundance is not available, the PBR level for the Alaska fin whale stock is undetermined (Allen and Angliss, 2015). Central North Pacific blue whale and Eastern North Pacific sei whale stocks may range into Alaska waters: PRB for blue whales is 0.10, and for sei whales is 0.17 for these stocks (Carretta et al., 2015). The projected annual increases in ship strikes from LNGC for these large baleen whales of 0.047 represents 17 percent of the combined PBR of 0.27 for these endangered whales.

The PBR for the Western North Pacific (WNP) humpback whale stock is 3.0 and the PBR for the Central North Pacific (CNP) entire stock is 82.8. The projected increase in ship strikes from LNGC for humpback whales of 0.094 represents 3 percent of the PBR for the WNP humpback whale stock if all strikes were of members of this stock and would represent 0.1 percent of the PBR for the CNP stock. Both stocks feed in the regions that would be transited by LNGCs, although the CNP is much more abundant.

Despite the low overall risk of ship strike to Cook Inlet marine mammals, due mostly to the low densities of those species at most risk of being struck, the current level of risk would increase as a result of increased vessel traffic, especially LNGC traffic. In 2010, there were 480 ship port calls or transits in Cook Inlet (Eley, 2012). The expected number of annual LNGC port of calls (252) to the proposed LNG Facility at Nikiski would increase the number of Cook Inlet port of calls by about 50 percent, to over 730 annually.

5.4 FUEL RELEASE

An inadvertent fuel release from a vessel could be a large spill involving the rupture of a vessel fuel tank, usually as a result of a collision, sinking, fire, or running aground. None of the construction vessels would be hauling fuel as payload, so maximum spill would be limited to the content of diesel in the fuel tank at the time of accident. BOEM (2016) analyzed the risk and effects of fuel releases and other small petroleum spills in Cook Inlet, and concluded that the majority of small spills would be contained on a vessel or platform, and that refined spills that reach the water would evaporate and disperse within hours to a few days. They further indicated that those spills reaching the water have some potential to be contained by booms or absorbent pads. USACE (Brueggeman 2011) and USFWS (Johnson et al., 2011) provided assessments of small releases on marine mammals in the Beaufort Sea,

Oil effects to marine mammals that could result include skin contact with the oil, ingestion of oil, respiratory distress from hydrocarbon vapors, contaminated food sources, fouled baleen, and displacement from feeding areas (Geraci, 1990). Actual impacts would depend on the extent and duration of contact, and the characteristics (age) of the oil. Most likely, the effects of oil would be irritation to the respiratory membranes and absorption of hydrocarbons into the bloodstream (Geraci, 1990). If a marine mammal was present in the immediate area of fresh oil, it is possible that it could inhale enough vapors to affect its health. Inhalation of petroleum vapors can cause pneumonia in humans and animals due to large amounts of foreign material (vapors) entering the lungs (Lipscomb et al., 1994). Contaminated food sources, an inability to sieve krill due to oil-fouling of baleen, and displacement from feeding areas also may occur as a result of an oil spill. Long-term ingestion of pollutants, including oil residues, could affect reproductive success, but data is lacking to determine how oil may fit into this scheme for marine mammals. Oil can reduce the thermal effects of hair on sea lions resulting in death if significantly oiled, especially for pups. However, following the Exxon Valdez oil spill, Loughlin (1994) found no evidence of oil toxicity damage to Steller sea lions stranded or live-sampled, and the diesel fuel that Project vessels would be using quickly evaporates and dissipates relative to heavier oils (NRC, 2014).

Incidental spills are chemical spills which can be safely controlled at the time of release by shipboard personnel, do not have the potential to become an emergency within a short time, and are of limited quantity, exposure and potential toxicity. Incidental spills also include normal vessel operational discharges, such as release of ballast or bilge water that might contain oils or oily detergents from deck washdown operations. They also include accidental releases of small volumes of hydraulic fluids, motor fuels and oils, and other fluids used in normal ship operation, usually as a result of overfilling tanks. Incidental spills can also occur during vessel and transportation tank fueling at docks. The accumulation of a number of small spills can lead to impaired marine waters.

Outlines for an SPCC that each construction contractor would finalize upon contract award and that would include the necessary provisions for containment and cleanup of any accidental spills during construction have been developed. Operational plans would be developed for facilities that store fuel and for the LNGCs while in US waters to address emergency containment and spill cleanup.

6.0 POTENTIAL PROJECT NOISE EFFECTS

6.1 BASIS FOR ESTIMATING EFFECTS

NMFS (2016) has also issued technical guidance for assessing the effects of sound on marine mammal hearing. NMFS also provided recommendations specifically for the assessment of the effects of sound on marine mammals from this Project in a 15 September 2016 meeting regarding a planned petition for ITRs. The recommendations included: densities to be used for marine mammals; acoustic sources to be considered for assessment of exposures exceeding thresholds (takes); models to be used to estimate sound transmission loss with distance from the sound source; and methods for calculating the numbers of marine mammal exposures. The following sections describe the methods to calculate these exposures and the effects on marine mammals. The methods follow the NMFS (2016) technical guidance and the recommendations provided at the meeting.

In the process of obtaining an incidental take authorization, an assessment of the potential number of animals of each species that could be harassed from exposure to underwater sound levels exceeding thresholds is performed: impulsive sound levels greater than 160 dB re 1 μPa (rms) or continuous sound levels exceeding 120 dB re 1 μPa (rms). For activities such as pile driving, anchor pulling, docking, and dredging, the standard method is to determine the maximum area that would be ensonified in a day by sound levels exceeding threshold, then multiplying that area by the number of days the activity would occur, and then again by the density of the animals found within the ensonified area. This provides an estimate of the number of exposure events that could occur for each species.

There are five primary underwater sound sources that could potentially affect marine mammals:

- Impact sheet pile driving associated with the Marine Terminal and West Dock expansion construction, and possibly with the construction of the Mainline MOF;
- Vibratory pile driving associated with the Marine Terminal and West Dock expansion construction, and possibly with the construction of the Mainline MOF;
- Thruster operation during dynamic positioning, anchor handling, and trenching associated with pipelay of the Mainline across Cook Inlet;
- Dredging activity at the Marine Terminal; and
- Vessels associated with docking of construction (barging) and operation/LNGC vessels.

Currently, accurately quantifying the potential number of exposures for each species is limited because Project details are lacking for some activities. For example, it is not known which pile driving type (impact versus vibratory) would be used and when, and how many days of pile driving would occur. The duration of activity at the proposed Mainline MOF on the west side of Cook Inlet has also not been developed. Also, winter density estimates are not available for of marine mammals in Cook Inlet. For numbers of calculated exposures for each source see Draft Petition for Incidental Take Regulations for construction of the Alaska LNG Project in Cook Inlet, Alaska (Draft ITR Petition, AGDC 2017)

6.2 AREAS OF ENSONIFICATION

For purposes of evaluating potential take, the area ensonified by underwater sound levels exceeding 120 dB or 160 dB was calculated to determine the ZOI. The area or ZOI for non-shoreline-based activities (pipelay and dredging) was calculated using the formula of:

$$r^2 \times \pi = ZOI$$

For shoreline activities (pile driving and docking) the ZOI value was halved to assume that only half the area around a shoreline project is marine waters:

$$r^2 \times \pi \times 0.5 = ZOI$$

The value "r" in the model is the radius to threshold selected from Table 17. The estimated ZOIs calculated in this manner for unmitigated sound levels are found in Table 22. For all practical purposes, pile driving, anchor pulling, dredging, and docking occurs at fixed locations, thus their associated ZOIs are also essentially fixed. However, the pipelay barge moves for a short distance during a 24-hour period, thus the ZOI expands during that time. Still, the ZOI associated with anchor pulling remains great enough to subsume the pipelay barge ZOI (such as winching) regardless of the distance the barge travels in a day. Thus, the anchor handling ZOI would be used in the exposure calculations to represent noise associated with the pipelay.

Table 22. Distances to NMFS Threshold Isopleths and Associated ZOIs

Noise Source	Threshold	Radius to Threshold (mi)	ZOI (mi^2)
Impact Pile Driving (pipe)	160 dB	2.17	7.42
Impact Pile Driving (sheet)	160 dB	0.06	0.006
Vibratory Pile Driving (pipe)	120 dB	2.65	11
Vibratory Pile Driving (sheet)	120 dB	0.74	0.86
Pipelay Barge Operations	120 dB	0.57	1.01
Tug (Anchor Pulling)	120 dB	3.22	32.67
Dredging	120 dB	0.08	0.02
Tug & Barge (Docking)	120 dB	2.64	10.95
Carrier (Docking)	120 dB	2.54	10.09

6.3 ACTIVITY DAYS OR EVENTS

Estimating the number of exposure events requires an understanding of the number of days of activity for activities like pile driving, pipelay, and dredging operations, as well as the number of docking events for docking vessels. Available information to date is shown in Table 23.

Table 23. Duration (Number of Days or Events) by Activity

Activity	Location	Days or Events 2019	Days or Events 2020	Days or Events 2021	Days or Events 2022	Days or Events 2023	Days or Events 2024	Days or Events 2025	Days or Events 2026	Days or Events Total
Pile Driving	Marine Terminal									486 days
	Mainline MOF									TBD
	West Dock									57 days
Pipelay	Cook Inlet	-	-	-	25	84	-	-	-	109 days

Activity	Location	Days or Events 2019	Days or Events 2020	Days or Events 2021	Days or Events 2022	Days or Events 2023	Days or Events 2024	Days or Events 2025	Days or Events 2026	Days or Events Total
Dredging	Marine Terminal			233		100				333 days
	Mainline MOF									TBD
	Mainline Shore Crossings				31					
Tug and Barge (Docking)	Marine Terminal									190 events
	Mainline MOF									39 events
	West Dock									61 events

6.4 MARINE MAMMAL DENSITIES

6.4.1 Cook Inlet

The densities for three primary species inhabiting Cook Inlet in the vicinity of the Project area based on the annual aerial surveys conducted by NMFS in Cook Inlet between 2001 and 2012 (Rugh et al., 2005; Shelden et al., 2013).

6.4.1.1 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 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 NMFS surveyors often circled marine mammal groups to get an accurate count of group size.

6.4.1.2 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/25,440 square miles), but resulted in an unrealistically inflated density of 0.6335 seals per square mile. This inflated density is due to the bias created by the large number of hauled out harbor seals in the NMFS aerial survey database relative to offshore densities.

An alternative harbor seal density estimate was developed by taking the highest number of hauled out seals recorded during the NMFS aerial survey (650 seals) and dividing it by the area of upper Cook Inlet (1,480 square miles) resulting in a density of 0.439 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. NMFS has recognized that harbor seal density estimates derived from both methods above are inflated, especially given that only about 2.2 seals were observed per 24-hour period by Lomac-MacNair et al. (2013, 2014) during seismic surveys in previous years in upper Cook

Inlet. NMFS may develop alternative harbor seal density estimates in the near future (S. Young, NMFS, pers. comm.).

6.4.1.3 Beluga Whale

Goetz et al. (2012) modeled aerial survey data collected by NMFS 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.

The derived densities are provided in Table 24.

Table 24. Raw and Corrected Marine Mammal Density Estimates for Cook Inlet

Species [1]	Mean Density (animals/mi^2)
Beluga Whale (Marine Terminal)	0.00041
Beluga Whale (Mainline Crossing)	0.0277
Beluga Whale (Beluga MOF)	0.0953
Killer Whale	0.0015
Harbor Porpoise	0.0098
Harbor Seal	0.4390

[1] Northern sea otters may occur but are generally considered to not be present in Upper Cook Inlet; reliable density estimates have not been published but NMFS (Federal Register 81(93):2990) used a density of 6.2 / mi^2 for nearshore areas near Anchor Point in the Lower Cook Inlet

6.4.2 Prudhoe Bay

Density estimates were derived for bowhead whales, beluga whales, ringed seals, spotted seals, and bearded seals, as shown in Table 22. There are no available Beaufort Sea density estimates for gray whales or walrus, or extralimital species such as humpback whales, narwhals, and ribbon seals. Encountering these animals during the West Dock expansion would be unexpected. Polar bears are ice dependent, and would not be present in the water during the summer, although a few beach-stranded bears may wander past West Dock. The summer density derivations for the five species presented in Table 25 are provided in the following discussions.

Table 25. Marine Mammal Densities in the Beaufort Sea

Species	Density (animals/mi^2)
Bowhead Whale	0.0126
Beluga Whale	0.0073
Ringed Seal (winter)	0.1812
Ringed Seal (summer)	1.2639

Species	Density (animals/mi^2)
Spotted Seal (summer)	0.1263
Bearded Seal (summer)	0.0631

6.4.2.1 Bowhead Whale

The summer density estimate for bowhead whales was derived from July and August aerial survey data collected in the Beaufort Sea during the Aerial Surveys of Arctic Marine Mammals (ASAMM) program in 2012 and 2013. During this period, 276 bowhead whales were recorded along 15,260 miles of transect line, or 0.0180 whales per mile of transect line. Applying an effective strip half-width (ESW) of 0.72 mile (Ferguson and Clarke, 2013), results in an uncorrected density of 0.0049.

6.4.2.2 Beluga Whale

There is little information on summer use by beluga whales in the Beaufort Sea. Moore et al. (2000) reported that only nine beluga whales were recorded in waters less than 55 yards deep during 7,447 miles of transect survey effort, or about 0.0012 whales per mile. Assuming an ESW of 0.614 (Ferguson and Clarke, 2013), the derived uncorrected density would be 0.00119 whales per square mile. The same data did show much higher beluga numbers in deeper waters. During summer aerial surveys conducted during the 2012 ASAMM program (Clarke et al., 2013), five beluga whales were observed along 889 miles of transect in waters less than 22 yards deep and between longitudes 140°W and 154°W (survey Block 3 that includes Prudhoe Bay). This equates to 0.006 whales per mile of trackline and an uncorrected density of 0.0017 assuming an ESW of 0.38 miles. To be conservative, the higher density value was used in the exposure calculations.

6.4.2.3 Ringed Seal

Surveys for ringed seals have been conducted in the Beaufort Sea by Kingsley (1986), Frost et al. (2002), Moulton and Lawson (2002), Moulton et al. (2005), Green and Negri (2005), and Green et al. (2006, 2007). The shipboard monitoring surveys by Green and Negri (2005) and Green et al. (2006, 2007) were not systematically based, but are useful in estimating the general composition of pinnipeds in the Beaufort nearshore, including Prudhoe Bay. Frost et al.'s (2002) and Moulton et al.'s (2005) aerial surveys were conducted during ice coverage and represent the winter conditions when pile driving at West Dock is most likely to occur. Moulton et al. (2005) found summer ringed seal densities in the Beaufort Sea between Jones Islands and Camden Bay (including Prudhoe Bay) to range between 1.01 and 2.14 animals per square mile (average 1.58 animals per square mile) in waters greater than 3.2 yards deep, but only 0.181 per square mile in waters less than 3.2 yards. As West Dock is found in water less than 3.2 yards, the latter density was used in the calculations.

There are no reliable ringed seal summer density estimates for the Prudhoe Bay. However, the summer nearshore use by ringed seals is not limited by shore-fast ice, and summer densities may be similar to spring densities found in deeper waters by Moulton et al. (2005). Their 6-year average density was 1.26 seals per square mile, and represents a conservative summer density of ringed seals occurring in the vicinity of West Dock. This value would be used in any future calculations if pile driving were to occur in the summer.

6.4.2.3.1 Spotted Seal

Green and Negri (2005) and Green et al. (2006, 2007) recorded pinnipeds during barging activity between West Dock and Cape Simpson, and found high numbers of ringed seals in Harrison Bay, as well as peaks in spotted seal numbers off the Colville River Delta where haul out sites are located. Approximately 5 percent of all phocid sightings recorded by Green and Negri (2005) and Green et al. (2006, 2007) were spotted seals. Moulton and Lawson (2002) conducted summer surveys for seals near Prudhoe Bay and found spotted seals to comprise 10 percent of the ringed and spotted seal sightings. Applying the latter to the nearshore ringed seal density from Moulton et al. (2002) results in an estimated summer density of 0.127 seals per square mile. Spotted seals do not inhabit Prudhoe Bay during the winter.

6.4.2.3.2 Bearded Seal

Bearded seals were also recorded in Beaufort Sea nearshore waters, including Prudhoe Bay, by Green and Negri (2005) and Green et al. (2006, 2007), but at lower proportions to ringed seals than spotted seals. However, estimating bearded seal densities based on the proportion of bearded seals observed during the barge-based surveys results in density estimates that appear unrealistically low, compared to density estimates from other studies. For conservative purposes, the bearded seal density values used in this application are derived from Stirling et al.’s (1982) observations that the proportion of eastern Beaufort Sea bearded seals is 5 percent that of ringed seals, resulting in an estimated summer density of 0.063 seals per square mile. Bearded seals are migratory and do not inhabit Prudhoe Bay during the winter.

6.4.2.4 Polar Bear

Garner et al. (1998) estimated the winter density of polar bears offshore of Prudhoe Bay at 0.0137 bears per square mile, although densities may be somewhat less today (Bromaghin et al., 2015). Polar bears would not be affected by underwater noise levels, so the utility of the density estimate relates to airborne noise and visual activities.

6.5 EXPOSURE CALCULATIONS

Exposures of marine mammals to sound levels exceeding NMFS thresholds are expected to occur from pile driving, offshore pipelay, and vessel docking, based on the ZOIs, number of days/activities and animal densities presented above. These exposures would occur in two areas, Cook Inlet and Prudhoe Bay (West Dock).

6.5.1 Pile Driving

Preliminary determinations of the numbers of marine mammals that could be exposed to pile driving sound levels exceeding sound criteria thresholds were determined by multiplying the density for each species by the estimated number of days a particular pile driving session would occur, and then by the estimated ZOI for that activity depending on whether an impact or vibratory hammer is used. Once the type of equipment is selected and more information on pile size is known, exposure estimates will be provided.

As indicated in Section 5.1.3, various methods and models have been used to estimate distances to threshold with greatly varied results. The radii from Blackwell (2005) were used In the calculations in Tables 26 to 29, because the pile driving study was actually conducted in Cook Inlet, and are slightly more conservative or more representative of the pile sizes likely to be used with the Project than other Cook Inlet pile driving studies.

Table 26. Number of Marine Mammals Potentially Exposed to Sound Levels exceeding 160 dB from Impact Hammer Operation at the Proposed Project Marine Terminal.

Species	Corrected Density (#/km^2)	Days	ZOI (mi^2)	Exposures
Beluga Whale	0.00016	486	7.42	2
Harbor Porpoise	0.0038	486	7.42	36
Killer Whale	0.0006	486	7.42	6
Harbor Seal	0.1695	486	7.42	1,585

Note: Densities are expressed as number of animals per square kilometer (km2). The ZOI was determined using a 2.2 mile radius (calculated from Blackwell 2005).

Table 27. Number of Marine Mammals Potentially Exposed to Received Sound Levels exceeding 120 dB from Vibratory Hammer Operation at the Proposed Project Marine Terminal

Species	Corrected Density (#/km^2)	Days	ZOI (mi^2)	Exposures
Beluga Whale	0.00016	486	11.01	2
Harbor Porpoise	0.0038	486	11.01	53
Killer Whale	0.0006	486	11.01	8
Harbor Seal	0.1695	486	11.01	2,349

The ZOI was determined by using a 2.6 miler radius (calculated from Blackwell 2005).

Table 28. Number of Marine Mammals Potentially Exposed to Received Sound Levels exceeding 160 dB from Impact Hammer Operation at the Proposed Mainline MOF

Species	Corrected Density (#/km^2)	Days	ZOI (mi^2)	Exposures
Beluga Whale	0.0368	45	7.42	32
Harbor Porpoise	0.0038	45	7.42	3
Killer Whale	0.0006	45	7.42	1
Harbor Seal	0.1695	45	7.42	147

The ZOI was determined using a 2.2 kilometer radius (calculated from Blackwell 2005).

Table 29. Number (#) of Marine Mammals Potentially Exposed to Received Sound Levels Greater than 120 dB from Vibratory Hammer Operation at the Proposed Mainline MOF

Species	Corrected Density (#/km^2)	Days	ZOI (km^2)	Exposures
Beluga Whale	0.0368	45	11.01	47

Harbor Porpoise	0.0038	45	11.01	5
Killer Whale	0.0006	45	11.01	1
Harbor Seal	0.1695	45	11.01	217

The ZOI was determined by using a 2.6 mile radius (calculated from Blackwell 2005).

Pile driving is planned to occur in the ice-free window over a 3-year period at the Marine Terminal. Thus, the average annual exposures are equivalent to the exposure values in Tables 26 and 27 divided by three. The very low beluga whale exposure estimates found in Table 19 are due to very low summer densities of beluga near Nikiski. The waters off Nikiski are, however, important wintering habitat for beluga whales. There are no winter density estimates, but presumably the potential number of exposures would increase significantly. The harbor seal exposure estimate is probably inflated due to bias in the density estimate (see Section 6.4.1).

The MOF on the west side of Cook Inlet is still in the planning stage and specific information on pile driving is currently unavailable. Assuming pile driving is not in the winter months, it is arbitrarily presumed that pile driving during construction of the MOF on the west side of Cook Inlet would last 45 days over 1 year. Exposure estimates are found in Tables 28 and 29.

Assuming a 45-day pile driving period over a single year results in an estimated 32 beluga whale exposures (from impact hammering), which is 9.4 percent of the current stock estimate (340; Allen and Angliss, 2015). This value is close to the 10 percent take limit imposed by NMFS (assuming no mitigation would occur). The exposure estimate for harbor seals is still probably inflated, but harbor seals are more common on the west side of the inlet than the east.

The estimated number of beluga exposures, if it were assumed that all pile driving would be done by a vibratory hammer, exceeds the 10 percent annual take currently allowed by NMFS (again assuming no mitigation). Vibratory hammering at the MOF on the west side of Cook Inlet could result in the largest number of potential exposure events of beluga whales, and would likely be limited in duration of use as well as the season of use.

Blackwell et al. (2004) did measure noise emanating from impact pile driving at the Northstar oil production island near Prudhoe Bay, but all actual pipe and sheet pile driving occurred terrestrially, resulting in relatively low sound levels into the adjacent marine waters. These measurements would not be representative of pile driving actually occurring within marine waters. However, pile driving at West Dock would occur during the winter. Bottom-founded, shore-fast ice would be removed prior to pile driving, resulting in a more “terrestrial” operation similar to that at Northstar. Blackwell’s highest SPL was 151 dB at 69 yards (in-water measurement), but the sound levels attenuated rapidly as the pathway was through and under shore-fast ice (as would occur at West Dock). Following their model (171.7 – 11.2 Log (r)), the pile driving sound would attenuate to 120 dB within about 0.76 miles from the dock. Given the nearest distance to the 3.5-yard depth contour, the delimit of ringed seal wintering habitat, is over 10,000 feet from West Dock, recognized ring seal wintering habitat would not be affected by pile driving noise. Even if it were assumed that all marine waters not shadowed by the West Dock causeway, within 0.76 miles of West Dock were affected, the number of potential ringed seal exposures would be expected to be very low.

6.5.2 Offshore Pipelay

Based on the literature, the loudest noise from pipelay is likely to emanate from drive propellers and dynamic positioning thrusters associated with the laybarge and anchor handling tugs. While thrusters are likely to operate only during short periods, it is assumed that they would operate daily (albeit intermittently), and other noise sources, such as trenching and winching, are subordinate. The eventual beluga whale exposure estimates may be high because of the size of the ZOI and the higher beluga densities near the western end of the pipeline route (Table 30). Approximately 6.8 miles (24 percent) of the proposed route occurs within the Susitna Delta exclusion area (within 10 miles of the mouth of the Beluga River). Currently, NMFS is restricting industrial activities that produce underwater sound above threshold to operating outside the Susitna Delta exclusion area between April 15 and October 15. The nearest point of the pipeline route (the western landfall near Beluga Landing) from the mouth of the Beluga River is 3.5 miles, or just beyond the estimated 3.22-mile range (to the 120-dB isopleth) of the loudest pipelay vessel sound (anchor pulling). Thus, while proposed activities are planned to occur within the exclusion zone, none of the pipelay sound is expected to extend to the Beluga River, the nearest location where summering beluga are expected to occur (based on noise propagation modeling using the 20 Log (r) spherical spreading model).

Table 30. Number of Marine Mammals Potentially Exposed to Received Sound Levels exceeding 120 dB from Anchor handling During Proposed installation of the Mainland Pipeline in

Species	Density (#/km^2)	Days	ZOI (mi^2)	Exposures
Beluga Whale	0.01071	109	32.67	99
Harbor Porpoise	0.0038	109	32.67	35
Killer Whale	0.0006	109	32.67	6
Harbor Seal	0.1695	109	32.67	1,563

The beluga whale exposure estimate is high because of the size of the ZOI and the higher beluga densities near the western end of the pipeline route. For the year 2022 alone, the estimated number of exposed belugas is 76, or over 22 percent of the stock size. Approximately 7 miles (24 percent) of the proposed route occurs within the Susitna Delta exclusion area (within 10 miles of the mouth of the Beluga River). Currently, NMFS is restricting industrial activities that produce underwater sound above threshold to operating outside the Susitna Delta exclusion area between April 15 and October 15. The nearest point of the pipeline route (the western landfall near Beluga Landing) from the mouth of the Beluga River is 7.2 miles, well beyond the estimated 3.2 mile range (to the 120-dB isopleth) of the loudest pipe-laying vessel sound (anchor pulling). Thus, while proposed activities are planned to occur within the exclusion zone, none of the pipe-laying noise is expected to extend to the Beluga River, the nearest location where summering beluga are expected to occur (based on noise propagation modeling using the 20 Log (r) spherical spreading model). Still, mitigation in the form of using protected species observers to ensure no beluga are in the area before anchor pulling may be necessary to ensure actual beluga exposures remain low.

6.5.3 Dredging Sound

Dredging is proposed to occur at or near the Marine Terminal (50.70 acres) and for trenching the pipeline shore approaches. Dredging is not expected to result in exposures to marine mammals that would require authorization from NMFS.

6.5.4 Vessel Docking Sound

Vessels operating in dynamic positioning mode produce continuous sound from thrusters exceeding 120 dB. Dozens of tug and barge trips would be needed annually to supply construction material to the Marine Terminal and Mainline MOF on the west side of Cook Inlet. In addition, several barge trips over four years would be required to deliver gas transfer unit (GTU) modules to West Dock. Finally, once the Marine Terminal is operating, there would be LNGCs arriving and leaving the terminal approximately once every 1.5 days. During each docking event, tugs or LNGCs would be operating their bow thrusters. Both tugs docking barges and docking LNGCs produce similar ZOIs: 10.95 square miles and 10.09 square miles, respectively (Tables 31 and 33). Small numbers of harbor seals and harbor porpoises would be expected to be exposed based on ZOIs, activity levels, and location. Very small numbers of belugas and killer whales would be expected to be exposed during Marine Terminal construction. The potential number of marine mammals exposed to vessel docking noise are found in Tables 31, 32, 33, and 34.

Table 31. Number of Marine Mammals Potentially Exposed to Received Sound Levels exceeding 120 dB from Tug and Barge Docking During Marine Terminal Construction

Species	Density (#/km^2)	Docking Events	ZOI (mi^2)	Exposures
Beluga Whale	0.00016	190	10.95	1
Killer Whale	0.0006	190	10.95	3
Harbor Porpoise	0.0038	190	10.95	20
Harbor Seal	0.1695	190	10.95	914

Table 32. Number of Marine Mammals Potentially Exposed to Received Sound Levels exceeding 120 dB from Tug and Barge Docking at the Mainline MOF

Species	Density (#/km^2)	Docking Events	ZOI (mi^2)	Exposures
Beluga Whale	0.0327	39	10.95	36
Killer Whale	0.0006	39	10.95	1
Harbor Porpoise	0.0038	39	10.95	4
Harbor Seal	0.1695	39	10.95	188

Table 33. Annual Number (#) of Marine Mammals Potentially Exposed to Received Sound Levels Greater than 120 dB from LNGC Docking During Proposed Marine Terminal Operations

Species	Density (#/km^2)	Docking Events	ZOI (mi^2)	Exposures
Beluga Whale	0.00016[1]	274	10.09	1
Killer Whale	0.0006	274	10.09	4
Harbor Porpoise	0.0038	274	10.09	27
Harbor Seal	0.1695	274	10.09	1,214

[1]Summer density. There is no winter density estimate for Cook Inlet beluga whales.

Table 34. Number (#) of Marine Mammals Potentially Exposed to Received Sound Levels Greater than 120 dB from Tug and Barge Docking During Module Delivery at West Dock

Species	Density (#/km^2)	Docking Events	ZOI (mi^2)	Exposures
Bowhead Whale	0.0049	61	10.95	8
Beluga Whale	0.0028	61	10.95	5
Ringed Seal	0.4880	61	10.95	845
Spotted Seal	0.0488	61	10.95	84
Bearded Seal	0.0244	61	10.95	42

These exposure estimates are spread over 4 years. Based on a recent marine mammal survey in Prudhoe Bay (Lomac-MacNair et al., 2014), the ringed seal exposure estimate is probably way too high, and the spotted seal estimate low.

Construction plans are still under development for the Mainline MOF on the west side of Cook Inlet. However, much higher exposure estimates may be associated with vessel docking at the Mainline MOF compared to similar activity at the Marine Terminal due to the higher beluga whale density estimate for the region near the Mainline crossing of the western shore of Cook Inlet and the close (7-mile) proximity to summering habitat at the mouth of the Beluga River.

Activity levels and ZOIs for vessel docking indicate that most of the exposures that are likely to occur at West Dock due to vessel docking noise would be ringed seals, but small numbers of spotted seals, bearded seals, and bowhead whales may be exposed.

The values in Table 33 represent the annual number of potential exposures and assume that an LNGC will arrive every 1.5 days. The number of potential beluga whale exposures is probably under-representative. The exposure estimate was calculated using the summer density estimate from Goetz et al. (2012), while the beluga winter density near Nikiski is probably higher. Goetz et al. (2012), while the beluga winter density near Nikiski is probably higher. These exposures would occur over the life of the project.

7.0 ANTICIPATED IMPACT OF THE ACTIVITY ON THE STOCK

7.1 INTRODUCTION

The primary impact of the Project to local marine mammals is acoustical harassment from impact and vibratory hammer operations during terminal and dock construction and modification, and anchor handling during pipelay across Cook Inlet.

7.2 BEHAVIORAL RESPONSE

7.2.1 Baleen Whales

Humpbacks, gray whales, and other large baleen whales, such as bowhead whales, have shown strong overt reactions to impulsive noises, such as seismic operations, at received levels between 160 and 173 dB re 1 µPa (rms) (Richardson et al., 1986; Ljungblad et al., 1988; Miller et al., 1999, 2005; McCauley et al., 2000). However, baleen whales seem to be less tolerant of continuous noise (Richardson and Malme, 1993), often detouring around drilling activity when received levels are as low as 119 dB re 1 µPa (rms) (Malme et al., 1983; Richardson et al., 1985). Based on the previously cited studies, NMFS developed the 120 dB re 1 µPa (rms) harassment criteria for continuous noise sources.

Other than observations that minke whales are often seen at visual ranges from drilling vessels off Greenland (Kapel, 1979), there is little information for this species specific to marine construction activities. Information on minke reactions to boats is varied. These whales have been observed to avoid approaching boats and yet will approach boats when the boats are stationary (see Richardson et al., 1995). Relative to bigger ships, information is lacking. Ship strikes are not an issue with baleen whales during construction because all vessels (pipelay, support tugs, and barges) move at speeds less than 10 knots.

7.2.2 Beluga Whale

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, 2002). 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 noise 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, 1995). A study conducted by Markowitz and McGuire (2007) found that while beluga whale numbers were generally low in the vicinity of the Port of Anchorage Marine Terminal Redevelopment Project, 64 percent of the groups observed entered the proposed Project footprint (which extended offshore about 164 yards).

7.2.3 Harbor Porpoise

Harbor porpoise are thought to be naturally shy and tend to move away from boats and ships. Reaction to boats can be strong when within 437 yards (Polacheck and Thorpe, 1990) out to 0.9 miles (Barlow, 1988). There is little information on harbor porpoise reaction to impulsive noise such as pile driving. However, Lucke et al. (2009) recently exposed harbor porpoise to impulsive noise signals and found that harbor porpoises showed behavioral aversion to impulsive sounds as low as 174 dB re 1 µPa (peak-peak), indicating a greater sensitivity to impulsive noise than beluga whales. Acoustical harassment devices with full spectrum impulsive source levels of 180 dB re 1 µPa effectively deterred harbor porpoise from salmon pens (Johnston, 2002).

7.2.4 Dall's Porpoise

Dall's porpoise are known to have an affinity for bow-riding both large and small vessels (Jefferson et al., 2010). 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.

7.2.5 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 noises. However, killer whales are sensitive to impulsive noises (such as pile driving) as evidenced by the effective use of acoustical harassment devices to protect salmon pen fisheries (Morton and Symonds, 2002).

7.2.6 Pinnipeds

Literature suggests that pinnipeds may be tolerant of underwater industrial noises, and they are less sensitive to lower frequency noises. In her review of the known effects of noise on marine mammals, Weilgart (2007) largely confined her discussion to cetaceans and only once mentioned a possible negative effect on pinnipeds. 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 noise, especially if food sources were present. Williams et al. (2006) failed to find any ringed seal response to pile driving and an ice road at the Northstar drilling island north of Prudhoe Bay.

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).

7.3 TEMPORARY THRESHOLD SHIFT AND PERMANENT THRESHOLD SHIFT

Sound has the potential to induce temporary (temporary threshold shift [TTS]) or permanent (permanent threshold shift [PTS]) hearing loss (Weilgart, 2007). The level of loss is dependent on sound frequency, intensity, and duration. Similar to 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.

7.4 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 noises 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. (2009) found that California blue whales (*Balaenoptera musculus*) have shifted their call frequencies downward by 31 percent since the 1960s, possibly in an attempt 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 noise levels. Fin whales have reduced their calling rate in response to boat noise (Watkins, 1986), and were thought to stop singing altogether for weeks in response to seismic surveys (IWC, 2007).

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 kilohertz, with best hearing between 30 to 50 kilohertz. Awbrey et al. (1988) examined their hearing in octave steps between 125 hertz and 8 kilohertz, with average hearing thresholds of 121 dB re1 µPa at 125 hertz and 65 dB re 1 µPa at 8 kilohertz. Johnson et al. (1989) further examined beluga hearing at low frequencies, establishing that the beluga whale hearing threshold at 40 hertz was 140 dB re 1 µPa. Ridgway et al. (2001) measured hearing thresholds at various depths down to 330 yards at frequencies between 500 hertz and 100 kilohertz. Beluga whales showed unchanged hearing sensitivity at this depth. Lastly, Finneran et al. (2005) measured the hearing of two belugas, describing their auditory thresholds between 2 and 130 kilohertz. In summary, these studies indicate that beluga whales hear from approximately 40 hertz to 130 kilohertz, with maximum sensitivity from approximately 30 to 50 kilohertz. 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.

7.5 STRESS AND MORTALITY

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 (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.

Monitoring hormonal levels in free-ranging marine mammals is difficult and most evidence is by extension from studies on terrestrial species or from studies on marine mammals where stress could not be isolated as the primary pathological causation (NRC, 2003). Romano et al. (2001, 2004) did, however, expose captive beluga whales to typical seismic airgun sound (226 dB re 1 μPa), much louder than impact pile driving, and initially found no changes in hormonal or immune response levels (Romano et al., 2001), but did find stress-level hormones in a follow up study (Romano et al., 2004) that remained at stress levels for up to an hour. 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.

Pipelay across Cook Inlet would occur near summer beluga concentration areas, with the primary sound source from drive propeller and thruster cavitation during anchor pulling, which extends about 2.64 miles to the 120-dB isopleth (Blackwell and Greene, 2005). 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 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.

8.0 IMPACT OF ACTIVITY ON MARINE MAMMAL SUBSISTENCE USE

The proposed Marine Terminal construction activities would occur closest to the marine subsistence area used by the Native Villages of Salamotof and Kenai, while the offshore pipeline and Mainline MOF would occur within the subsistence use area used by Villagers from Tyonek. 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. There are no harvest quotas for other non-listed marine mammals found there. ADF&G (Wolfe et al., 2009) has regularly conducted surveys of harbor seal subsistence harvest in Alaska. Since 1992, Alaska Natives from Cook Inlet Villages (Homer, Kenai, Tyonek, Anchorage) have annually taken (harvested plus struck and lost) between four and 111 harbor seals. Most of these seals were harvested by Alaskan Natives living in Anchorage, followed by Tyonek Villagers. It is unclear where Anchorage-based hunters actually harvest animals (some may be taken in lower Cook Inlet), but Tyonek and Kenai hunters are likely to harvest near the Village. (There is no harbor seal harvest information for Salamotof.) There were no reported harvest of sea lions by any of the Cook Inlet Villages during the 1992 to 2008 (the most recently published) survey period (Wolfe et al., 2009). The Project's planned Marine Terminal construction and Mainline pipelay activities would not impact harbor seals in sufficient numbers to render them unavailable for subsistence harvest in Cook Inlet.

The West Dock expansion activities would occur within Prudhoe Bay, which is located nearly 62 miles east of Nuiqsut and 118 miles west of Kaktovik. Subsistence harvest reports (Brower and Hepa, 1998; Brower et al., 2000) for these Villages indicate that Prudhoe Bay is not used by either Village for the purpose of marine mammal subsistence harvest, largely due to the travel distance relative to high success hunting areas much closer to these Villages. Any temporary disturbance of local seal populations at West Dock would not affect the regional subsistence harvest essentially because subsistence harvest does not occur there.

Proposed barging activity to West Dock would occur, however, during both the bowhead migration and annual fall bowhead hunt. Because of the limited open water season at Prudhoe Bay, and its time constraints on Project success, there are no plans to limit barging activity during the fall hunt. The Alaska Eskimo Whaling Commission (AEWC) and the North Slope Borough would be consulted to develop and implement mitigation measure to limit potential impacts to the fall hunt.

9.0 IMPACT OF THE ACTIVITY UPON THE HABITAT

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.

9.1 COOK INLET

The Marine Terminal construction and Mainline pipelay activities would occur in upper Cook Inlet. Cook Inlet is a large Subarctic estuary roughly 186 miles in length and averaging 60 miles in width. It extends from the city of Anchorage at its northern end and flows into the Gulf of Alaska at its southernmost end. For descriptive purposes, Cook Inlet is separated into unique upper and lower sections, divided at the East and West Forelands, where the opposing peninsulas create a natural waistline in the length of the waterway, measuring approximately 10 miles across (Mulherin et al., 2001).

Upper Cook Inlet is the area between Point Campbell (Anchorage) down to the Forelands, and is roughly 60 miles in length and 15 miles in width (Mulherin et al., 2001). 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 60 feet in depth. It is characterized by shoals, mudflats, and a wide coastal shelf, less than 60 feet deep, extending from the eastern shore. A deep trough exists between Trading Bay and the Middle Ground Shoal, ranging from 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 13 feet at the Gulf of Alaska end to 28.8 feet near Anchorage (USACE, 2013). Tidal currents reach 6.6 feet per second (3.9 knots) (Mulherin et al., 2001) in upper Cook Inlet, increasing to 9.8 to 13 feet per 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).

9.1.1 Potential Effects on Marine Mammal Habitat in Cook Inlet

Potential impacts on marine mammal habitats include those associated with increases in underwater sound pressure levels from pile driving and vessel propeller/thruster operation, temporary habitat loss from dredging and pipelay, and permanent changes to the habitat associated with construction and use of the Marine Terminal.

9.1.1.1 Potential Effects of Pile Driving

Underwater sound generated by construction of the Mainline and the Marine Terminal would have no lasting effect on the habitat; its effects being limited largely to the behavioral effects on the marine mammals themselves as discussed in Section 7.2 and 6.0.

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 2005b). 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 at this time (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.

Short-term turbidity is a water quality effect of most in-water work, including installing piles. Roni and Weitkamp (1996) monitored water quality parameters during a pier replacement project in Manchester, Washington. The study measured water quality before, during, and after pile removal and pile replacement. The study 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.

9.1.1.2 Potential Effects of Seafloor Disturbance on Marine Mammal Habitat

The primary effects on water quality and on the sea floor would be associated with dredging for the MOF, trenching / burial of the pipeline at the shore crossings and mooring of the pipelay vessel as the pipe is installed across Cook Inlet.

Approximately 1,636 acres of seafloor would potentially be impacted by dredging, dredge disposal, pipeline installation / trenching at the shore crossings, and pipelay vessel mooring during construction. These physical effects on relief would be expected to be manifest for only months over 2 or more years because of the short duration of construction and the high energy and dynamic nature of the Cook Inlet seafloor and water column in these open water areas. The area would be immediately available to marine mammals at the end of construction. There would be a loss of benthic organisms in these areas, but re-colonization to similar communities would be expected to be rapid. Endemic communities in Cook Inlet must be able to colonize and re-colonize locations quickly because of the dynamic shifting of sediment on the seafloor. Polycheates, which represent a large portion of the benthic community are known to rapidly colonize disturbed habitat. Shellfish such as razor clams would also be expected to rapidly re-colonize intertidal areas along the Mainline route, perhaps in a single season (BOEM 2016). However, upper Cook Inlet supports a low abundance and diversity of marine invertebrates (Saupe et al., 2005). No areas of ecological importance or special importance to marine mammals, such as razor clam beds or kelp or seagrass beds would be impacted. An additional 13 acres of seafloor would be would be impacted by construction of the MOF. These habitats would only recover once the MOF is removed.

Permanent impacts to the marine mammal habitats would be associated with the offshore portion of the Mainline within Cook Inlet and the PLF. The 42-inch diameter pipeline would occupy approximately 11 acres of seafloor. Benthos under the pipe would be lost to marine mammals, but some invertebrates may colonize the pipe surface. Marine mammals would use the water column above the pipe. The PLF occupies an area of about 19 acres, but this is based on the surface area of the deck. The PLF is supported on pilings and therefore occupies a much smaller area of the seafloor. The 19 acre PLF area would largely be a permanent loss of marine mammal habitat.

9.1.2 Potential Effects on Cook Inlet Beluga Critical Habitat

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

9.1.2.1 Intertidal and Subtidal Waters of Cook Inlet with Depths <30 Feet (MLLW) and within 5 Miles of High and Medium Flow Accumulation Anadromous Fish Streams

The shore crossing of the Mainline on the west side of Cook Inlet is located within 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 5 miles of an anadromous stream (Bishop Creek). The Marine Terminal is located more than 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 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 on this Primary Constituent Element would be temporary and minor given the amount of available habitat of this type within Cook Inlet.

9.1.2.2 Primary Prey Species – Pacific Salmon, Pacific Eulachon, Pacific Cod, Saffron Cod, Yellowfin Sole

Construction of the Marine Terminal, pipelay, and construction vessel traffic would not be expected to have a noticeable effect on the above beluga prey species. The species could potentially be affected by: the sound generated by geophysical and geotechnical equipment, physical disturbance of the fish habitat, discharges associated with vessels, or geotechnical borings.

Any acoustical effects to beluga prey resources, including Pacific salmon, Pacific eulachon, Pacific cod, saffron cod, and yellowfin sole, are limited and would be negligible, if they occur. Cooling water and ballast water exchanges.

9.1.2.3 The Absence of Toxins or Other Agents of a Type or Amount Harmful to Beluga Whales

Seafloor sediments to be disturbed during construction of the Marine Terminal and pipelay across the Inlet are not known to be contaminated. 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. The program would have no effect on this Primary Constituent Element. Hydrostatic test waters and wastewaters from the construction camp and operation facilities at the Liquefaction Facility would meet State water quality standards.

9.1.2.4 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. All of these activities would be conducted in relatively open areas of Cook Inlet within Critical Habitat Area 2. Given the size and openness of Cook Inlet in the survey areas, and the relatively 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 Primary Constituent Element.

9.1.2.5 The Absence of In-Water Noise at Levels Resulting in the Abandonment of Habitat by Cook Inlet Beluga Whales

Operation of the construction and pipelay equipment would generate sound with frequencies within the beluga hearing range and at levels above threshold values (Section 6.5), 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. The dimensions of ZOIs that would be ensonified to received sound levels exceeding NMFS thresholds for Level B harassment of marine mammals, are provided in Section 6.2. These ZOIs would represent small portions of the critical habitat area available to the belugas. All these activities would take place within critical habitat Area 2. Impacts from sound energy are temporary, lasting only as long as the activity is being conducted.

In 2011, subsequent to designation of critical habitat for Cook Inlet beluga whales, NMFS issued a BO (NMFS, 2011) analyzing the effects of the Port of Anchorage Marine Terminal Development 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, NMFS analyzed the effect of the MTRP on the PCE values of habitat in the excluded area as well. NMFS 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). NMFS 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 action on that value, NMFS 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, NMFS 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, NMFS’ BO concluded that the action, as proposed, is not likely to destroy or adversely modify Cook Inlet beluga whale critical habitat. Although PCE 5 may indicate that the habitat is adversely affected, it is NMFS’ opinion that critical habitat will remain functional and able to serve its intended conservation role for Cook Inlet beluga whales.

The Mainline and Marine Terminal would be located in 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. As discussed previously, the Project may affect critical habitat by introducing noise and additional vessel traffic. However, these effects are not likely to diminish the value of the primary constituent elements 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. 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. Therefore, the Project is not likely to adversely modify critical habitat for the Cook Inlet beluga whale.

9.2 PRUDHOE BAY

Benthic infauna abundance is very low in front of DH4, and diversity is very low in these areas, due to the effects of grounded winter ice (Carey et al., 1984). Polychaete worms and the small (less than 0.2 inch) bivalve *Axinopsida orbiculata* are abundant at depths at between 16 and 49 feet (Carey et al., 1984). Mega-epifaunal species were found by Carey et al. (1984) to occur mostly in the 54- to 820-yard water depths. Only a few brittlestars (*Ophiocten sericeum*) and mud scallops (*Arctinula greenlandicus*) were found in water depths less than 27 yards, albeit at lower densities than in deeper (greater than 109 yards) waters. The only Prudhoe Bay marine mammal that feeds extensively on benthic fauna is the bearded seal (although ringed seals will feed on benthic isopods), but none of the above species were identified in Cameron et al.'s (2010) comprehensive literature view of bearded seal diet. All three seals (ringed, spotted, bearded) and beluga whales feed on fish, which in turn often feed on polychaete worms. However, the low nearshore densities of benthic prey suggest that proposed construction activity would have little effect on marine mammal feeding ecology.

9.2.1 Potential Effects on Polar Bear Critical Habitat

USFWS identified three PCEs for polar bear critical habitat: sea ice habitat, terrestrial denning habitat, and barrier island habitat, as described below, and designated three critical habitat units based on these PCEs.

9.2.1.1 Sea Ice Habitat

This PCE was described as sea ice habitat used for feeding, breeding, denning, and movements, which is sea ice over waters 300 m (984.2 ft) or less in depth that occurs over the continental shelf with adequate prey resources (primarily ringed and bearded seals) to support polar bears. Construction of the Project would be expected to have only very minor and temporary effects on this PCE. As an existing structure, West Dock is technically not part of the critical habitat but the proposed West Dock modifications in Prudhoe Bay would be. Dock expansion would encompass approximately 31 acres of the habitat, but these effects would be minor as the footprint area receives little use by polar bears or ringed seals. Additional acreage would be affected by emplacement of the barge bridge, but these activities would be limited to the ice free period.

9.2.1.2 Terrestrial Denning Habitat

Terrestrial denning habitat, which includes topographic features, such as coastal bluffs and river banks, with suitable macrohabitat characteristics. Suitable macrohabitat characteristics are: (a) Steep, stable slopes (range 15.5–50.0°), with heights ranging from 4.3 to 111.6 feet., and with water or relatively level ground below the slope and relatively flat terrain above the slope; (b) unobstructed, undisturbed access between den sites and the coast; (c) sea ice in proximity of terrestrial denning habitat prior to the onset of denning during the fall to provide access to terrestrial den sites; and (d) the absence of disturbance from humans and human activities that might attract other polar bears.

Small amounts of potentially suitable den habitat would be permanently affected as a result of facility construction and would temporarily affect an area of potentially suitable den habitat through ice road and pad construction. The GTP may alter habitat suitability for a small area around the facility as a result of noise generated during operation. Winter construction activities would temporarily reduce potentially suitable den habitat.

9.2.1.3 Barrier Island Habitat

This PCE includes all barrier island habitat used for denning, refuge from human disturbance, and movements along the coast to access maternal den and optimal feeding habitat. This includes all barrier islands along the Alaska coast and their associated spits, within the range of the polar bear in the United States, and the water, ice, and terrestrial habitat within 1 mi of these islands (no-disturbance zone). No Project activities are planned on or within 1.0 mile of barrier islands habitat, therefore no effects on this critical habitat unit and PCE would be expected.

10.0 IMPACT OF THE LOSS OR MODIFICATION OF THE HABITAT ON THE MARINE MAMMAL POPULATIONS

Construction of the Marine Terminal and laying the Mainline pipeline would result in a minor modification or loss of marine benthic habitat in Cook Inlet, mostly from dredging and shading from overwater structures. In addition, laying of gravel and expansion of West Dock and barge bridge, would alter the existing benthic community in Prudhoe Bay in a localized small area around the existing west dock. The estimated benthic habitat modification and loss is provided in Table 28. Modification is defined as movement of benthic habitat, while permanent loss occurs by the construction of over-water structures or gravel placement.

Table 35. Permanent and Temporary Loss of Benthic Habitat from the Project

Activity	Permanent Loss (acres)	Temporary Loss (acres)	Total Loss (acres)
PLF	18.67	18.67 [1]	18.67
Shoreline Stabilization	0	1.54	1.54
Temporary MOF	0	11.32 [1]	11.32 [1]
Temporary MOF Dredging Area	0	50.70 [1]	50.70
Dredge Spoil Disposal	0	1,200 (600 acres/year during construction)	1,200 (600 acres/year during construction)
Mainline Crossing	330.11	38,131.76	330.11
West Dock Expansion	0	31.05	0
Barge Bridge at West Dock	0	2.58	0

[1] The MOF is a total of 28.3 acres; however, 16.98 acres is included within the MOF dredging area footprint.

11.0 MITIGATION MEASURES

The activities of most concern regarding noise harassment to marine mammals include pile driving, anchor pulling, and thruster use during tug and carrier docking. The former two are considered discreet, non-routine actions with the potential for Level A harassment. The latter carries less Level A harassment potential, is of short duration, and allows ample time for marine mammals to move away from the stimulus. Docking is also a routine part of operations. Implementation of mitigation measures, such as shutdown zones, is impractical for a number of reasons, thus, mitigation focuses on pile driving and anchor handling.

11.1 ROUTING

- 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.

11.2 MARINE CONSTRUCTION

- All Contractors would comply with the Project's *Spill Prevention, Control, and Countermeasure (SPCC) Plan* (Resource Report No. 2, Appendix M).
- Dock Head 4 piles and sheet would be installed in winter or otherwise outside of the bowhead fall migration period.
- Regulatory agencies would be consulted to (if determined to be needed) survey with traditional hunters or specially trained dogs any ice road or construction activities that may occur after March 1 in previously undisturbed areas in waters deeper than 10 feet (3 meters) to identify and avoid ringed seal structures by a minimum of 492 feet (150 meters).

The primary means of minimizing impacts to marine mammals during pile driving and anchor handling include: 1) establishing shutdown safety zones to ensure marine mammals are not injured by noise levels exceeding Level A injury thresholds; 2) establishing shutdown safety zones 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; 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; and 5) timing survey activity to seasonally avoid concentrations of beluga whales (upper Cook Inlet) and other listed marine mammals. In addition, choosing impact pile driving over vibratory pile driving could be considered a mitigation measure given the smaller ZOI, and use of bubble curtains and wood block silencers to reduce noise levels would be considered. The latter has been shown to reduce noise levels at the higher frequencies, which are more likely to overlap with local marine mammal hearing.

Reducing and mitigating acoustical impacts to local marine mammals during Project activity will be more specifically addressed in the *Marine Mammal Monitoring and Mitigation Plan* (*4MP*) after construction plans are finalized and impacts are more precisely known.

11.3 LAND CONSTRUCTION

- Bear monitors would watch for polar bears and deter polar bears from Project activities, as necessary, using USFWS-approved deterrent methods.

- Procedures and communications protocols would be implemented for polar bear encounters and plan would be updated as necessary to ensure current contacts and procedures would be incorporated.
- Personnel would attend training programs, such as *Arctic Pass*, which would cover polar bear and wildlife awareness.
- Current polar bear issues would be communicated to workers through bulletins, posters, and safety meetings.
- FLIR surveys would be conducted prior to winter construction for potential maternal polar bear dens. If a den is located during construction or operations, activity would be shut down, an exclusion zone near the den would be established, and 24-hour monitoring of the den site would be implemented to limit human-bear encounters and allow the female bear to naturally emerge from and leave the den site.
- USFWS would be consulted if an active polar bear den is discovered within 1 mile of the ice road route after construction.
- Spill prevention and response programs would be implemented.
- All Contractors would comply with the Project's *Spill Prevention, Control, and Countermeasure (SPCC) Plan* (Resource Report No. 2, Appendix M).

11.4 WASTE MANAGEMENT

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.

11.5 PERMITS

- Measures in the *Wildlife Avoidance and Interaction Plan* would be implemented, which include the *Polar Bear and Pacific Walrus Avoidance and Interaction Plan* provided in Resource Report No. 3, Appendix J.
- Measures in the Draft *Marine Mammal Mitigation and Monitoring Plan* provided in Resource Report No. 3, Appendix N, would be implemented for noise and activity associated with West Dock construction activities, marine dredging activities, and marine vessel traffic.

11.6 NATIVE AGREEMENTS

- A Conflict Avoidance Agreement with the Alaska Eskimo Whaling Commission would be considered.
- Applicable protective measures for a POC provided in Resource Report No. 3, Appendix O, would be established and implemented with subsistence users.

11.7 VESSELS

- All Project-related vessels would comply with USCG 33 C.F.R. 151 and EPA requirements for ballast water discharge.

- Sealift barging would be planned to be completed prior to the main fall bowhead whale migration and subsistence whaling.
- HLV and LNGC traffic would be routed well offshore of the Aleutian Islands whenever possible in compliance with the proposed Aleutian ATBAs.
- Oil spill response plans for vessel groundings or other accidental releases of oil would be implemented.
- The West Dock modifications would be constructed to reduce the total number of barge trips.
- Fixed wing and rotary wing aircraft flights over marine waters would be at altitudes of 1,500 feet or greater except during landing, take-offs, or bad weather or other flying condtions.

12.0 CONCLUSIONS

The construction actions associated with the Project could potentially affect marine mammals inhabiting the waters of Cook Inlet and the Beaufort Sea. In addition, vessel traffic associated with construction and operation would additionally occur in North Pacific, Bering Sea, and Chukchi Sea waters. This MMPA assessment evaluated potential impacts to marine mammals under the jurisdiction of both NMFS and USFWS.

LNGC routes to foreign markets would transit through lower Cook Inlet into the North Pacific. If the Great Circle Route to Asia is followed, then these carriers could enter the Bering Sea via Unimak Pass. LNGCs generally follow offshore routes and are less likely to encounter coastal species such as gray whales, harbor porpoise, harbor seals, and sea otters.

12.1 COOK INLET

Marine mammals identified as potentially occurring in the proposed Project area within Cook Inlet include:

- Humpback whale – Humpback use of Cook Inlet has been observed to be largely confined to lower Cook Inlet. Humpback whales will move about their range and it is possible for a small number of these whales to visit the Marine Terminal area. However, because of a lack of food, humpbacks are unlikely to venture north into the proposed upper Cook Inlet pipeline crossings.
- Minke whale – There are no records north of Cape Starichkof, and this species is unlikely to be seen in upper Cook Inlet. However, it is quite possible for minke whales to occasionally travel as far north as Nikiski (i.e., the Marine Terminal area).
- Gray whale – Despite several sitings in lower Cook Inlet, gray whales would not be expected to be encountered in upper Cook Inlet, where there are no records of their activity. The most likely location gray whales may be encountered would be along the Kenai Peninsula south of Ninilchik. It is possible that gray whales may occasionally travel as far north as Nikiski.
- Beluga whale – Beluga whales could be found in the vicinities of the pipeline crossings during summer-fall and the Marine Terminal area during winter. The proposed Project area would be located in Critical Habitat Area 2.
- Harbor porpoise – Harbor porpoise have been observed throughout Cook Inlet during the summer months, they represent a species that could be encountered at the Marine Terminal and the proposed upper Cook Inlet pipeline crossings.
- Dall's porpoise – There is a remote chance that Dall's porpoise might travel to the northern reaches of lower Cook Inlet (such as near Nikiski).
- Killer whale – The sporadic movements and small numbers of this species suggest that there is a rare possibility of encountering this whale at the Marine Terminal construction and the proposed upper Cook Inlet pipeline crossings. There is a greater possibility of encountering killer whales during vessel transits through lower Cook Inlet or the Bering Sea.

- Steller sea lion – Steller sea lions inhabit lower Cook Inlet, but are rarely seen in upper Cook Inlet. There is a small chance that this species could occasionally occur near the Marine Terminal and the proposed upper Cook Inlet pipeline crossings.
- Harbor seal – harbor seals are one of the more common marine mammal species in Alaskan waters. During summer, small numbers of harbor seals are expected to occur in the vicinity of both the Marine Terminal and along the proposed Mainline pipeline crossing route.

Additional details of these species, their potential presence in the proposed Project area, and potential Project-related impacts are provided in the Biological Assessment in Appendix C of Resource Report No. 3.

Marine mammals may be affected by noise from construction activities and interaction with vessels during construction and operation of the Marine Terminal and Liquefaction Facility. Anticipated effects include disturbance and temporary displacement from the Marine Terminal and Liquefaction Facility areas due to noise and presence of construction equipment. The Project could potentially affect marine mammals in Cook Inlet, including beluga whale critical habitat through:

- Noise and disturbance from construction and operation at the Marine Terminal and Liquefaction Facility and construction of a MOF on the west side of Cook Inlet near the Mainline shore crossing;
- Noise and disturbance from construction of the Mainline across upper Cook Inlet;
- Noise and potential vessel strikes from heavy lift vessel (HLV) and LNGC traffic in Cook Inlet;
- Vessel grounding and subsequent potential fuel spills;
- Habitat modification from dredging;
- Indirect effects on anadromous prey;
- Impacts to beluga whale critical habitat from construction of the Mainline and MOF;
- Impacts to beluga whale critical habitat from construction and operation of the Marine Terminal and Liquefaction Facility.

Relative to Cook Inlet marine mammals, especially beluga whales, the activities with the greatest potential to result in Level B harassment include proposed pile driving and tug and barge docking at the Mainline MOF, and anchor relocation for the laybarge during the pipelay across Cook Inlet. This is primarily because of higher summer beluga densities along the western shore of upper Cook Inlet coupled with large ZOIs (unmitigated) from both vibratory and impact pile driving, and pulling anchors associated with the laybarge. Proposed pile driving at the Marine Terminal is not expected to be much of a concern because summer beluga densities are low near Nikiski. Pile driving at West Dock is proposed for the winter, when few marine mammals are available to be exposed. Harbor and ringed seal densities are inflated due to inherent bias in how these animals are surveyed and densities estimated. NMFS is working on developing new density estimates for both species.

Most of the Project's construction activities in Cook Inlet would focus on the Marine Terminal, which is located south of the Forelands where beluga whales are less abundant, particularly during the ice-free period and in summer months when they are typically foraging in the Upper Cook Inlet estuaries and river mouths in and near Knik Arm. Reports of vessel strikes involving beluga whales are rare; most small cetaceans are adept at avoiding vessels, particularly large commercial vessels that tend to transit at steady speeds on predictable courses.

12.2 PRUDHOE BAY

Marine mammals identified as potentially occurring in the proposed Project area within Prudhoe Bay include:

- Bowhead whale – The West Dock construction and seabed preparation activities would occur in waters depths where bowhead whales are rarely observed. Migrating bowheads could be encountered by barging traffic to West Dock during the fall, but encounters could be limited by following nearshore traffic routes.
- Gray whale – Few gray whales have ever been reported in the Beaufort Sea as far east as Cape Halkett. The occurrence of gray whales in Prudhoe Bay is not expected.
- Beluga whale – Beluga whales could potentially occur in the vicinity of West Dock during summer and fall periods, but occurrences would be relatively rare.
- Ringed seal – Winter densities of ringed seal are low near shore because of grounded ice limiting available water habit. Pupping activity is not expected to occur in the vicinity of West Dock because of shallow water depths, although winter lair records indicate some use in relatively shallow Prudhoe Bay waters.
- Spotted seal – Spotted seals have been observed in Prudhoe Bay, including several in the immediate vicinity of West Dock, during past monitoring in July-August. Spotted seals seasonally leave the Beaufort Sea to winter in the Bering Sea.
- Bearded seal – Based on surveys in the Prudhoe Bay area during the open-water period, only very small numbers of bearded seals would be expected in the vicinity of West Dock.
- Polar bear – Polar bears den both on land and over ice in the general region of Prudhoe Bay and Point Thomson, and may den along the Beaufort Sea coast wherever deep snow drift conditions conducive to denning are present. However, West Dock and Point Thomson are active industrial areas and are likely unattractive for denning. Some Project activities would take place within the terrestrial denning habitat unit of polar bear critical habitat.

Additional details of these species, their potential presence in the proposed Project area, and potential Project-related impacts are provided in the Biological Assessment in Appendix C of Resource Report No. 3.

Marine mammals may be affected by noise from construction activities and interaction with vessels during construction of the required West Dock improvements and the barge delivery of modules. Anticipated effects include disturbance and temporary displacement from the immediate area and presence of construction equipment. The Project could potentially affect marine mammals in Prudhoe Bay through:

- Noise and disturbance from construction and module offloading at West Dock;
- Noise and potential vessel strikes from barge traffic in Prudhoe Bay;
- Vessel grounding and subsequent potential fuel spills; and
- Indirect effects on anadromous prey.

Pile driving for West Dock modifications, would occur during the winter. Only polar bears and ringed seals are found in Prudhoe Bay during the winter.

12.3 CONSERVATION MEASURES

The following are potential conservation measures to avoid adverse effects to marine mammals, including Cook Inlet beluga whale critical habitat:

- To the greatest extent practicable, avoid designated beluga whale Critical Habitat Area 1;
- To the greatest extent practicable, time construction activities to avoid and minimize potential impacts to marine mammals during the open-water season;
- Monitor construction activities with potential for acoustic harassment to ensure that marine mammals are not exposed to noise that would cause injury or harassment;
- Ensure that all Project-related vessels comply with USCG 33 C.F.R. 151 for ballast water discharge;
- Ensure that all Contractors comply with the Project's *Spill Prevention, Control, and Countermeasure (SPCC) Plan* (Appendix M in Resource Report No. 2).

12.4 EFFECTS ON SPECIES

The Project could affect marine mammals during construction activities and by vessel traffic primarily through potential acoustic impacts.

The Project could result in disturbance of individual marine mammals as a result of vessel traffic. These effects are likely to minor and transitory, having little impact on the fitness of exposed individuals, and would be indistinguishable from normal shipping traffic. Ship strikes from vessels associated with construction or operations could occur; however, the probability of such an event is low. An oil spill from a vessel grounding could be injurious or lethal to exposed animals. However, the probability of such an event is low and would be mitigated through implementation of oil spill prevention and response plans.

With implementation of conservation measures listed, the Project may affect, but is not likely to adversely affect any marine mammal species.

13.0 ACRONYMS AND TERMS

Term	Definition
μPa	MicroPascal
4MP	Marine Mammal Monitoring and Mitigation Plan
AEWC	Alaska Eskimo Whaling Commission
AHT	anchor handling tug
ASAMM	Aerial Surveys of Arctic Marine Mammals
ASD	Azimuth Stern Drive
BOEM	Bureau of Ocean Energy Management
C.F.R.	Code of Federal Regulations
dB	decibel
dBA	A-weighted decibel
DPS	Distinct Population Stock
ESA	Endangered Species Act
ESW	effective strip half-width
GTP	Gas Treatment Plant
GTU	gas transfer unit
HLV	heavy lift vessel
IMS	Ice Mitigation Structure
IWC	International Whaling Commission
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
Lo/Lo	lift-on/lift-off
LOA	Letter of Authorization
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MOF	Material Offloading Facility
MONM	Marine Operations Noise Model
NMFS	National Marine Fisheries Service
North Slope	Alaska North Slope
NTU	nephelometric turbidity units
PBU	Prudhoe Bay Unit
PLF	Product Loading Facilities
PTS	permanent threshold shift
PTU	Point Thomson Unit
Ro/Ro	roll-on/roll-off

Term	Definition
SPCC	Spill Prevention, Control, and Countermeasure
SPL	sound pressure level
STP	seawater treatment plant
TTS	temporary threshold shift
U.S.	United States
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
ZOI	zone of influence

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