



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

National Marine Fisheries Service

P.O. Box 21668

Juneau, Alaska 99802-1668

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion
Alaska Liquefied Natural Gas (LNG) Project

NMFS Consultation Number: AKRO-2018-01319

Action Agencies: National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division; Federal Energy Regulatory Commission

Affected Species and Determinations:

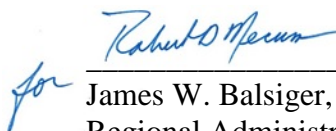
ESA-Listed Species and Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU)	Status	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely to Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Bowhead whale (<i>Balaena mysticetus</i>)	Endangered	Yes	n/a	No	n/a
Blue whale (<i>Balaenoptera musculus</i>)	Endangered	No	n/a	No	n/a
Fin whale (<i>Balaenoptera physalus</i>)	Endangered	Yes	n/a	No	n/a
Humpback whale, Western North Pacific DPS (<i>Megaptera novaeangliae</i>)	Endangered	Yes	n/a	No	n/a
Humpback whale, Mexico DPS (<i>Megaptera novaeangliae</i>)	Threatened	Yes	n/a	No	n/a
North Pacific right whale (<i>Eubalaena japonica</i>)	Endangered	No	No	No	No
Sperm whale (<i>Physeter macrocephalus</i>)	Endangered	Yes	n/a	No	n/a
Ringed seal, Arctic subspecies (<i>Phoca hispida hispida</i>)	Threatened	Yes	n/a	No	n/a
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	Threatened	Yes	n/a	No	n/a
Steller sea lion, Western DPS (<i>Eumetopias jubatus</i>)	Endangered	No	No	No	No



ESA-Listed Species and Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU)	Status	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Cook Inlet beluga whale (<i>Delphinapterus leucas</i>)	Endangered	Yes	No	No	No
Gray whale, Western North Pacific DPS (<i>Eschrichtius robustus</i>)	Endangered	No	n/a	No	n/a
Sei whale (<i>Balaenoptera borealis</i>)	Endangered	No	n/a	No	n/a
Chinook salmon (<i>Oncorhynchus tshawytscha</i>) ESU					
Lower Columbia River	Threatened	No	No	No	No
Upper Columbia River Spring	Threatened	No	No	No	No
Puget Sound	Threatened	No	No	No	No
Snake River Fall	Threatened	No	No	No	No
Snake River Spring/Summer	Threatened	No	No	No	No
Upper Willamette River	Threatened	No	No	No	No
Steelhead trout (<i>Oncorhynchus mykiss</i>) DPS					
Lower Columbia River	Threatened	No	No	No	No
Middle Columbia River	Threatened	No	No	No	No
Snake River Basin	Threatened	No	No	No	No
Upper Columbia River	Threatened	No	No	No	No
Upper Willamette River	Threatened	No	No	No	No
Puget Sound	Threatened	No	No	No	No

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:


for James W. Balsiger, Ph.D.
Regional Administrator

Date:

June 3, 2020

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TERMS AND ABBREVIATIONS

Ω	Saturation state
2D	Two-dimensional
3D	Three-dimensional
4MP	Marine Mammal Monitoring and Mitigation Plan
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AGDC	Alaska Gasline Development Corporation
AHT	Anchor handling tug
AIS	Automatic Identification System
AK LNG	Alaska Liquefied Natural Gas (project)
AKR	(NMFS) Alaska Regional Office
ANC	Anchorage International Airport
Apache	Apache Alaska Corporation
APDES	Alaska Pollutant Discharge Elimination System
APU	Alaska Pacific University
ASAMM	Aerial Surveys of Arctic Marine Mammals
ATB	Articulated tug barge
ATBA	Aleutian Islands Areas to be Avoided (International Maritime Organization)
AWTF	Anchorage John M. Asplund Wastewater Treatment Facility
BA	Biological Assessment
bbbl	Barrels
Bbbl	Billion barrels
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
BSAI	Bering Sea/Aleutian Islands
BSEE	Bureau of Safety and Environmental Enforcement
BWASP	Bowhead Whale Feeding Ecology Study
BWM	Ballast water management
CFR	Code of Federal Regulations
CGF	Central Gas Facility
CI	Confidence Interval
CO ₂	Carbon dioxide
COE	(United States Army) Corps of Engineers

CV	Coefficient of variation
CWA	Clean Water Act of 1972
dB re 1 μ Pa	Decibel referenced 1 microPascal
dBA	A-weighted sound level
DEIS	Draft Environmental Impact Statement
DH	Dock head
DPS	Distinct Population Segment
DQA	Data Quality Act
DWH	Deepwater Horizon
EEZ	(U.S.) Exclusive Economic Zone
EIS	Environmental Impact Statement
EMALL	ExxonMobil Alaska Liquefied Natural Gas LCC
ENA	Kenai Municipal Airport
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESCA	Endangered Species Conservation Act
ESU	Evolutionarily Significant Unit
°F	Fahrenheit
FAI	Fairbanks International Airport
FERC	Federal Energy Regulatory Commission
FMP	Fishery Management Plan
FR	<i>Federal Register</i>
ft	Feet
GIS	Geographic Information System
GOA	Gulf of Alaska
GP	General permit (U.S. Army Corps of Engineers)
GT	Gross tonnage
GTP	Gas treatment plant/facilities
HAB	Harmful algal bloom
HF	High-frequency (cetacean hearing group)
hr	Hour(s)
Hz	Hertz
IHA	Incidental Harassment Authorization
IPCC	Intergovernmental Panel on Climate Change
ITS	Incidental Take Statement
IWC	International Whaling Commission
kHz	kiloHertz

KLU	Kitchen Lights Unit
JBER	Joint Base Elmendorf-Richardson
km	kilometer
kn	Knots
L_E	Cumulative sound exposure at reference value of $1\mu\text{Pa}^2\text{s}$
L_{pk}	Peak sound pressure at $1\mu\text{Pa}$
LF	Low frequency (cetacean hearing group)
LNG	Liquefied natural gas
LNGC	LNG carrier
LOA	Letter of Authorization
Lo-Lo	Lift-on/Lift-off
LOWC	loss of well control
μPa	Micro Pascal
m	meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MF	Mid-frequency (cetacean hearing group)
mgd	Million gallons per day
MHHW	Mean higher high water
mi	mile
MLLW	Mean lower low water
MLV	Mainline valves
MML	Marine Mammal Laboratory (of the Alaska Fisheries Science Center)
MMPA	Marine Mammal Protection Act
MOF	Material Offloading Facility
MP	Milepost
mph	Miles per hour
MTSA	Marine transit staging area
NEG	Primary sealift
nm	Nautical mile
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
OPR	Office of Protected Resources
OW	Otariid pinniped underwater (hearing group)
PBF	Physical or Biological Feature
PBOSA	Prudhoe Bay Offshore Staging Area
PBTL	Prudhoe Bay Unit Gas Transmission Line

PBU	Prudhoe Bay Unit
PCB	polychlorinated biphenyls
PCE	Primary Constituent Element
PIC	Person in Charge
PK	Peak sound level
PLF	Product Loading Facility
POA	Port of Alaska
PSO	Protected Species Observer
PTTL	Point Thomson Unit Gas Transmission Line
PTS	Permanent threshold shift
PTU	Point Thomson Unit
PW	Phocid pinniped underwater (hearing group)
rms	Root mean square
Ro-Ro	Roll-on/Roll-off
RPA	Reasonable and prudent alternative
s	seconds
SEA	Seattle-Tacoma International Airport
SCC	Deadhorse Airport
SD	Standard deviation
SEL	Sound exposure level
SPCC	Spill prevention, control, and countermeasure plan
SPL	Sound pressure level
SPMT	Self-propelled module transporter
SSV	Sound source verification
STP	Seawater Treatment Plant
SUDEX	Susitna Delta Exclusion Zone
TL	Transmission loss
TTS	Temporary threshold shift
UME	Unusual Mortality Event
U.S.C.	United States Code
USDOT	United States Department of Transportation
USFWS	U.S. Fish and Wildlife Service
VGP	Vessel general permit (EPA NPDES)
VLOS	Very large oil spill (>150,000 barrels)

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. § 1536(a)(2)) requires each Federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, that agency is required to consult with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR § 402.14(a)). Federal agencies may fulfill this general requirement informally if they conclude that an action may affect, but "is not likely to adversely affect" endangered species, threatened species, or designated critical habitat, and NMFS or the USFWS concurs with that conclusion (50 CFR § 402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agency's action is likely to affect ESA-listed species and their critical habitat. If incidental take is reasonably certain to occur, section 7(b)(4) requires the consulting agency to provide an incidental take statement (ITS) that specifies the impact of any incidental taking, specifies those reasonable and prudent measures necessary or appropriate to minimize such impact, and sets forth terms and conditions to implement those measures.

In this document, the action agencies are the NMFS Office of Protected Resources – Permits and Conservation Division ("Permits Division") and the Federal Energy Regulatory Commission (FERC). The Permits Division proposes to issue the Alaska Gasline Development Corporation (AGDC) a Letter of Authorization (LOA) for incidental harassment of marine mammals in Cook Inlet, and an Incidental Harassment Authorization (IHA) for incidental harassment of marine mammals in Prudhoe Bay. Both authorizations are associated with a proposed new liquefied natural gas (LNG) pipeline. FERC proposes to authorize AGDC to build and operate the pipeline and appurtenant facilities. The consulting agency for this proposal is NMFS's Alaska Region (NMFS AKR). This document represents NMFS's biological opinion (opinion) on the effects of this proposal on endangered and threatened species and designated critical habitat.

The opinion and Incidental Take Statement (ITS) were prepared by NMFS Alaska Region in accordance with section 7(b) of the ESA (16 U.S.C. § 1536(b)), and implementing regulations at 50 CFR part 402.

The opinion and ITS are in compliance with the Data Quality Act (44 U.S.C. § 3504(d)(1)) and underwent pre-dissemination review.

1.1 Background

This opinion considers the effects of the construction of a LNG pipeline and related facilities. The pipeline will run from Prudhoe Bay through the interior of Alaska, and will cross Cook Inlet from the west side near the existing Beluga Landing to the liquefaction plant in Nikiski. These actions have the potential to affect the endangered Cook Inlet distinct population segment (DPS)

of beluga whale (*Delphinapterus leucas*), endangered bowhead whale (*Balaena mysticetus*), endangered blue whale (*Balaenoptera musculus*), endangered fin whale (*Balaenoptera physalus*), endangered Western North Pacific DPS and threatened Mexico DPS humpback whale (*Megaptera novaeangliae*), endangered North Pacific right whale (*Eubalaena japonica*), North Pacific right whale critical habitat, endangered sperm whale (*Physeter macrocephalus*), endangered Western North Pacific DPS gray whale (*Eschrichtius robustus*), endangered sei whale (*Balaenoptera borealis*), threatened Arctic ringed seal (*Phoca hispida hispida*), threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*), endangered Western DPS Steller sea lion (*Eumetopias jubatus*), Steller sea lion critical habitat, multiple Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant units (ESUs); Lower Columbia River, Upper Columbia River spring-run, Puget Sound, Snake River fall-run, Snake River spring/summer-run, and Upper Willamette River), and six steelhead trout (*Oncorhynchus mykiss*) DPSs (Lower Columbia River, Middle Columbia River, Upper Columbia River, Puget Sound, Snake River Basin, and Upper Willamette River).

This opinion is based on information provided by AGDC in the Revised IHA Application for the proposed activities in Prudhoe Bay (AGDC 2020a) and the petition for an LOA for the proposed activities in Cook Inlet (AGDC 2020b), the Draft Environmental Impact Statement (DEIS) and Biological Assessment (BA) by FERC published on June 28, 2019 (FERC 2019), Proposed LOA (84 FR 30991; June 28, 2019), the updated project proposals, email and telephone conversations between NMFS Alaska Region, NMFS Permits Division, FERC, and AGDC; and other sources of information. A complete record of this consultation is on file at NMFS's Anchorage, Alaska office.

1.2 Consultation History

- January 5, 2018: AGDC submitted LOA petition (Cook Inlet)
- October 2, 2018: AGDC submitted revised LOA petition (Cook Inlet)
- March 28, 2019: AGDC submitted IHA application (Prudhoe Bay)
- May 21, 2019: AGDC submitted a revised IHA application (Prudhoe Bay)
- June 28, 2019: FERC released DEIS, including BA
- June 28, 2019: Proposed LOA rule (Cook Inlet) published in the Federal Register
- September 16, 2019: AGDC submitted a revised IHA application (Prudhoe Bay)
- October 31, 2019: AGDC submitted a revised IHA application (Prudhoe Bay)
- August 30, 2019: NMFS deemed the consultation package complete
- November 2019: NMFS, FERC, and AGDC agreed to extend the ESA section consultation from January 1, 2020 to June 4, 2020
- April 29, 2020: AGDC agreed to a revised set of mitigation measures
- May 22, 2020: NMFS Permits Division requested consultation

2 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

2.1 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. 50 C.F.R. § 402.02.

This opinion considers the effects of the NMFS Permits Division’s Marine Mammal Protection Act (MMPA) authorization to AGDC for incidental takes of marine mammals, and FERC’s authorization to AGDC to build and operate a natural gas pipeline and appurtenant facilities in Alaska (Figure 1). The Mainline Pipeline is proposed to start at the Gas Treatment Facilities on the North Slope at Prudhoe Bay and generally follow the existing Trans Alaska Pipeline System crude oil pipeline through interior Alaska. The Mainline Pipeline is proposed to cross Cook Inlet from near Beluga Landing on the west side of Cook Inlet to near Suneva Lake on the east side of Cook Inlet on the Kenai Peninsula, ending at the Liquefaction Facilities in Nikiski, Alaska.

The full project description can be found in the DEIS (FERC 2019)¹. While this project is comprised of many terrestrial components, only the project activities and facilities with a potential to affect ESA-listed species and critical habitat under NMFS’s jurisdiction are described in this opinion.

This consultation on the construction and operational phases of the project is based on information provided by FERC, NMFS Permits Division, and AGDC. Additional consultation may be required if future federal actions occur that are not currently reasonably foreseeable or if there are unanticipated effects related to pipeline operations and maintenance.

¹ <https://www.ferc.gov/industries/gas/enviro/eis/2019/06-28-19-DEIS.asp> Accessed May 20, 2020.

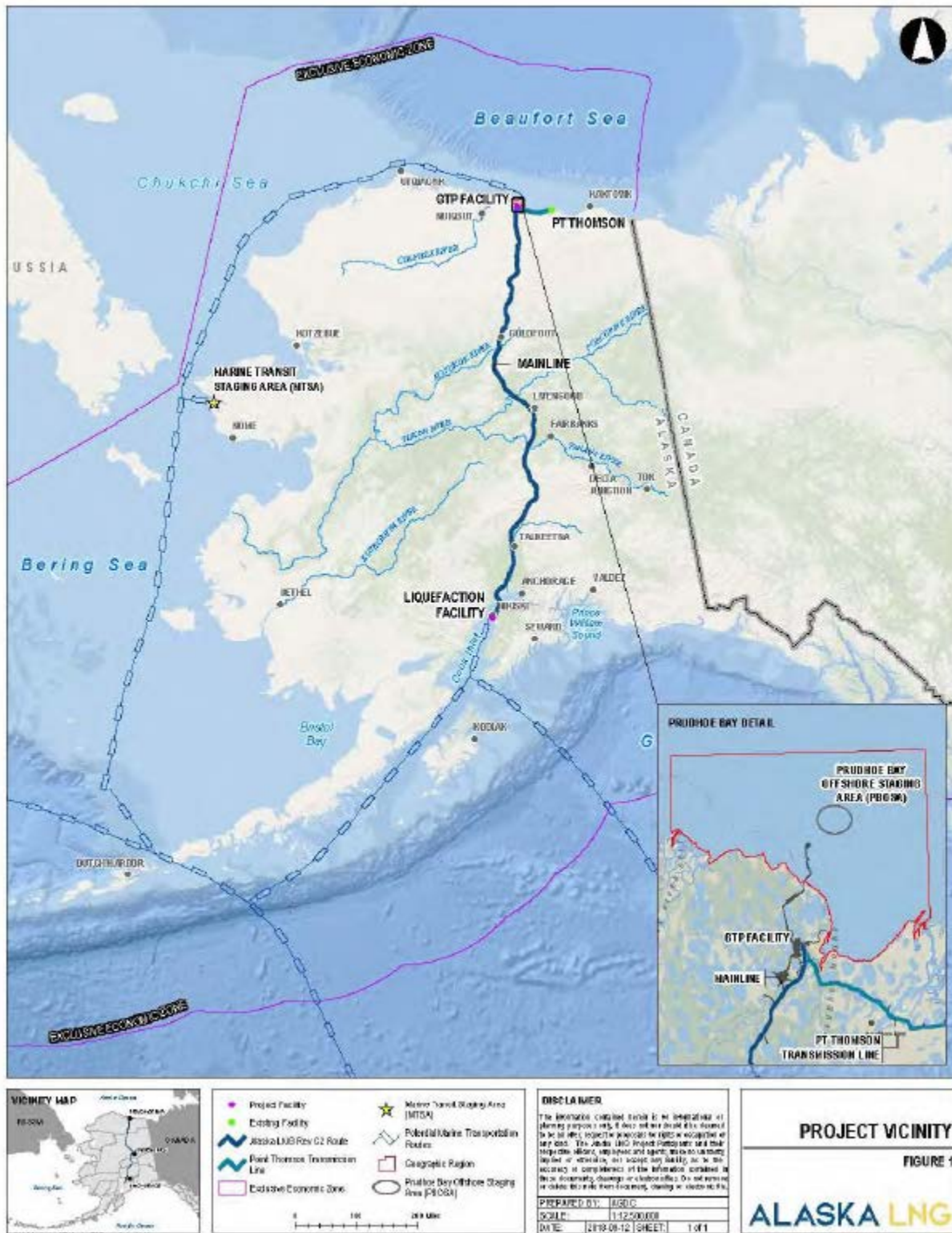


Figure 1. Map of the proposed Alaska LNG pipeline project

2.1.1 Proposed Activities

2.1.1.1 Prudhoe Bay – Gas Treatment Facilities

The proposed activities on the northern end of the pipeline will occur on and around West Dock, an existing causeway located on the northwest shore of Prudhoe Bay, Alaska, within the Prudhoe Bay Unit (PBU; Table 1). West Dock is a multipurpose facility, commonly used to offload marine cargo to support Prudhoe Bay oilfield development. The West Dock causeway, which extends approximately 2.5 miles (4 km) into Prudhoe Bay from the shoreline, is a solid-fill gravel causeway structure that was constructed in multiple phases between 1974 and 1981 (Figure 2). There are two existing loading docks along the causeway, referred to as Dock Head 2 (DH2) and Dock Head 3 (DH3), and a seawater treatment plant (STP) at the seaward terminus of the structure. A 650-ft (198-meter) breach with a single lane bridge was installed in the causeway between DH2 and DH3 during 1995 and 1996 due to concerns that the solid causeway was impacting coastal circulation and marine resources.

The proposed Alaska LNG Gas Treatment Facilities/Plant (GTP; Figure 2 through Figure 4) will be constructed with large pre-fabricated modules that can only be transported to the North Slope with barges (sealift). An accessible and well-functioning dock facility will be required in Prudhoe Bay to receive these large modular components and as such, upgrades to dock and causeway infrastructure at West Dock are required for offloading the modules, and for transporting the modules to the GTP construction site.

The GTP will be a new facility in the PBU near the Beaufort Sea coast. The GTP will be on state land within the North Slope Borough in an area designated for oil and natural gas development. Components of the GTP are summarized below.

- three gas treatment systems (trains) to remove liquids and impurities from the natural gas
- control building
- on-site ancillary facilities, including flares, metering, fuel gas and propane pipelines, fuel systems, and byproduct pipelines
- utilities, including power generation facilities, water supply and treatment systems, sewage treatment, waste disposal (including two underground injection control Class 1 wells), and a communication tower
- Operations Center and camp

Table 1. Planned activities in Prudhoe Bay

Project Component/Activity	Activity	Year		
		2021	2022	2023-2027
Causeway Widening	Haul and deposit gravel ^a	*		
DH4 Construction	Haul and deposit gravel ^a	*		
	Install Sheet pile walls (pile driving) ^b	*		
	Install mooring dolphins (pile driving) ^b	*		
	Install bag armor ^a	*		
	Excavate overfill/re-compact gravel ^c		*	
	Prepare seabed / level berths (screeding) ^d		*	*
Barge Bridge and Abutments	Haul and deposit gravel ^e	*		
	Install bulkhead (pile driving) ^e	*		
	Install mooring dolphins (pile driving) ^e	*		
	Prepare barge bridge seabed pad ^f		*	*
	Install/remove barge bridge ^g		*	*
Sealift (Dutch Harbor to Prudhoe Bay)	Vessel transit ^h		*	*
	Offload materials / modules at DH4 ⁱ		*	*

^a Planned for June-September 2021

^b Planned for September-October 2021 outside of Nuiqsut whaling season

^c Planned for May-June 2022

^d Planned for July just after ice recedes 2022

^e Planned for July-August 2021

^f Initial preparation planned through the ice in February-April 2022, with additional minor smoothing in July 2022-2027

^g Barge bridge to be installed in August and removed in September 2022-2027

^h Vessels would transit Chukchi Sea and Beaufort Sea July-September 2022-2027

ⁱ Materials offloading (smaller modules, equipment, supplies) planned for August-September 2022-2023; GTP module offloading planned for August-September 2024-2027



Figure 2. Existing conditions at West Dock in Prudhoe Bay, Alaska

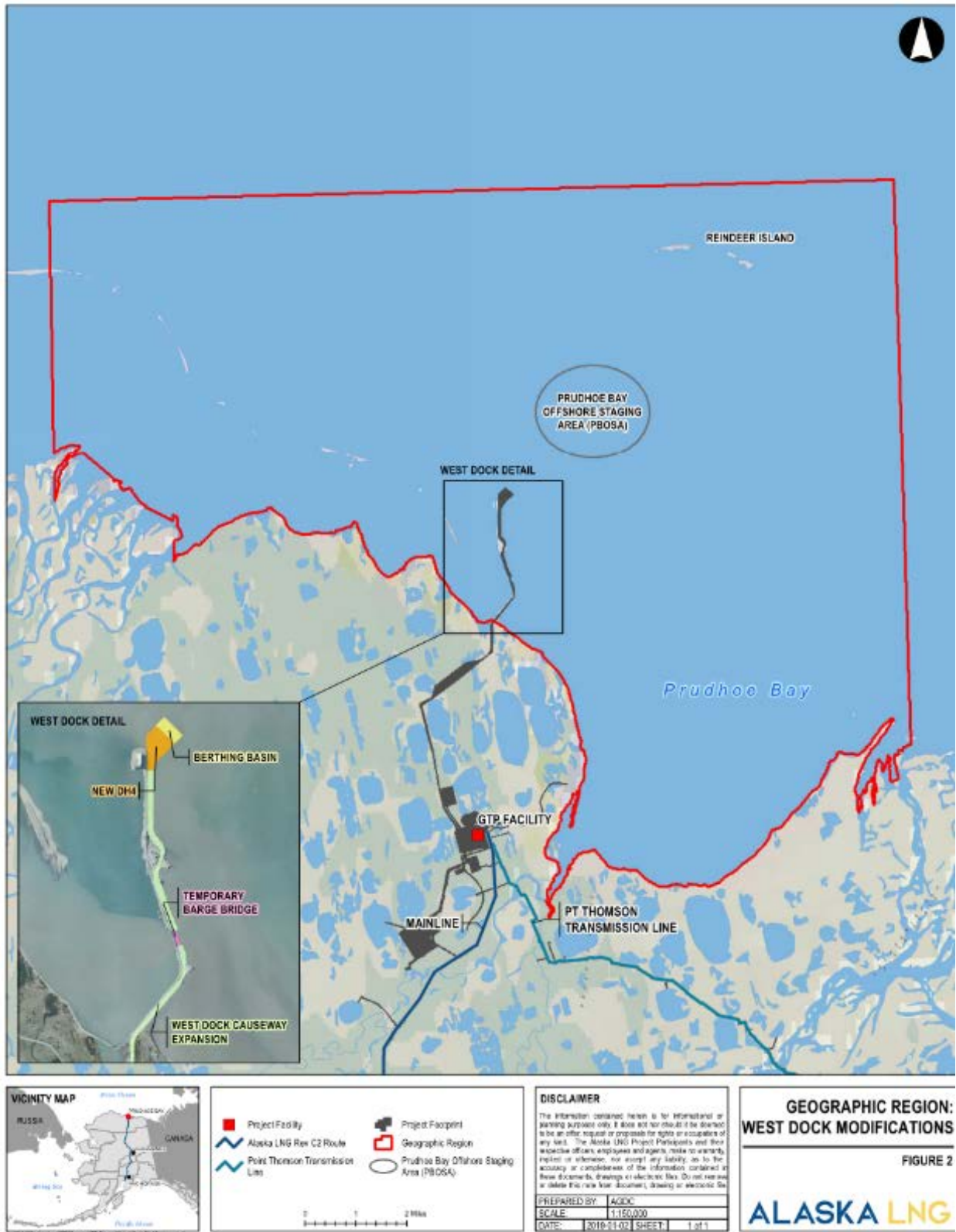


Figure 3. Proposed modifications to West Dock, Prudhoe Bay, Alaska for the Alaska LNG project



Figure 4. Gas treatment facilities in and adjacent to Prudhoe Bay, Alaska

West Dock Causeway

Development of the dock facility will require construction of a new dock head referred to as Dock Head 4 (DH4). The gravel causeway between the proposed DH4 site and the onshore road system is too narrow for module transport and must be widened in several areas. The existing bridge over the aforementioned breach is also too narrow for module transport and is not capable

of supporting the weight of the project modules (Figure 5). A temporary barge bridge is therefore proposed to accommodate transport of the modules over the breach. New sheet pile and gravel abutments will be constructed along the east side of the existing bridge, and four mooring dolphins will be installed. Two barges will then be placed along these mooring dolphins and between the abutments to form a temporary bridge for module transport. Sealifts and barge bridge installation/removal will occur in each of six consecutive years to accommodate the modules required for the project. The following describes these activities in detail.

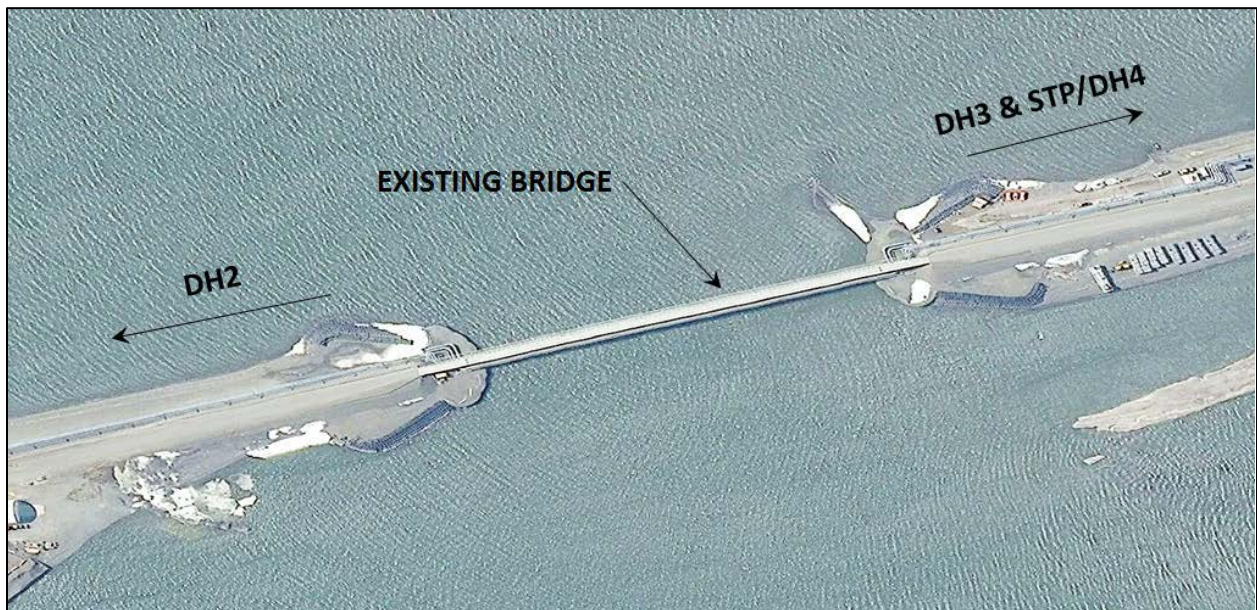


Figure 5. Existing conditions at the West Dock breach/bridge

Causeway Widening

Existing segments of the West Dock causeway will be upgraded as follows:

A parallel causeway approximately 100–125 ft (30.5–38.1 m) wide and 5,000-ft long (1,524-m long) will be built on the east side of the existing causeway from DH 3 to DH 4;

The two existing segments of West Dock causeway will be upgraded to a width of approximately 100–125 ft (30.5–38.1 m) from the current width of 40–80 ft (12.2–24.4 m). The widening will be conducted on the east side of the causeway because there is a pipeline along the west side.

The widening will occur along approximately:

- 4,500 ft (1,372 m) from DH3 to DH2, and
- 3,800 ft (1,158 m) from DH2 to land.

This causeway widening work will be conducted during the summer (July–August). Gravel will be hauled in by truck and deposited in place by shore-based heavy equipment. Expected gravel requirements are indicated in Table 2. The primary source of gravel will be a new (proposed) onshore mine located southwest of the GTP site and just north of the Putuligayuk River.

Table 2. Gravel requirements for proposed West Dock Causeway widening

Causeway Section	Gravel Quantity cubic yards (cubic meters)	Surface Area Acres (hectares)
1 – shore to barge bridge ¹	100,000 (76,455)	5 (2.0)
2 – barge bridge to DH3 ²	150,000 (114,683)	7 (2.8)
3 – DH3 to DH4	300,000 (229,366)	14 (5.7)
Total	550,000 (420,505)	26 (10.5)
¹ Includes the gravel to be placed behind the bulkhead at the south abutment of the barge bridge		
² Includes the gravel to be placed behind the bulkhead at the north abutment of the barge bridge		

DH4 Work Area, Bulkhead, and Mooring Dolphins

The new dock head will be a gravity-based structure, with a combi-wall (sheet piles connected by H piles) bulkhead or dock face back-filled with gravel. The gravel dock head will provide a working area of approximately 31 acres (0.13 km²) and will have 5 cargo berths (Figure 6). Gravel will be hauled in by truck and deposited in place by shore-based heavy equipment. Hauling and placement of gravel for construction of DH4 will occur in June–September. The quantity of gravel needed is outlined in Table 3.

Construction of DH4 as proposed will require the installation of over 1,080 linear ft (329 m) of combi-wall forming a bulkhead at the dock face (Figure 6). Other margins of the dock head will be sloped and armored with sand bags. Two types of hammers will be used for pile driving: vibratory hammers and impact hammers. The numbers and types of piles expected to be driven are indicated, by hammer type, in Table 4.

Table 3. Gravel requirements for proposed DH4 construction

Section	Gravel Quantity cubic yards (cubic meters)	Surface Area Acres (hectares)
DH4 Surface	1,200,000 (917,466)	30 (12.1)
DH4 Side Slope	50,000 (38,228)	3 (1.2)
Total	1,250,000 (955,694)	33 (13.3)

Table 4. Piles to be installed and removed at the proposed DH4

DH4 Component	Pile Type / Size	Method	Total Piles	Piles / Day	Duration / Pile (strikes or minutes)	Work Days
Bulkhead	11.5-in H pile ^{a,b}	Impact	212	26	1,000	9
Bulkhead	25-in sheet pile ^{a,e}	Vibratory	422	12	24.0	36
Mooring Dolphins	48-in pipe pile ^{a,c}	Impact	12	1.25	1,000	10
Mooring Dolphins	14-in H pile (temp) ^{a,d}	Vibratory	48	4	13.4	12
All	NA	--	694	NA	NA	67

^a All piles are steel.

^b These H piles are expected to be W 33x118 type steel H piles with width of 11.5 in each, length of 63 ft, and embedment depth of 43 ft; along with the sheet pile they form a combi-wall; days is the number of calendar days on which pile driving of 11.5 in H piles will be driven based on a rate of 25 ft linear (horizontal) ft of piles per day (total length 203 ft).

^c Mooring dolphins are expected to be (1) 48-in round steel pile each, with a length of 100 ft, and estimated embedment depth of 65 ft; days are calendar days during which these piles will be driven based on a rate of 1.25 piles per day.

^d Temporary spud piles used for support during installation of mooring dolphins, are assumed to be steel H piles, 14 in wide and 30 ft long, 4 per mooring dolphin. They are installed with vibratory hammer, then removed with vibratory hammer after mooring dolphin is installed; it takes 1 hour to install four spuds and 1 hour to extract them; however, with the hiatus between installation and extraction (for installing the mooring dolphin) we assume a rate of 4 spuds per day. Removal and extraction are expected to occur within the same day.

^e Sheet piles expected to be PZC18 Type steel sheets with a width of 25 in each, length of 63 ft, and estimated embedment depth of 43 ft; the total horizontal length of sheet pile is 859 ft; days is the number of calendar days sheet piles will be driven based on a rate of 25 linear (horizontal) ft of piles per day.

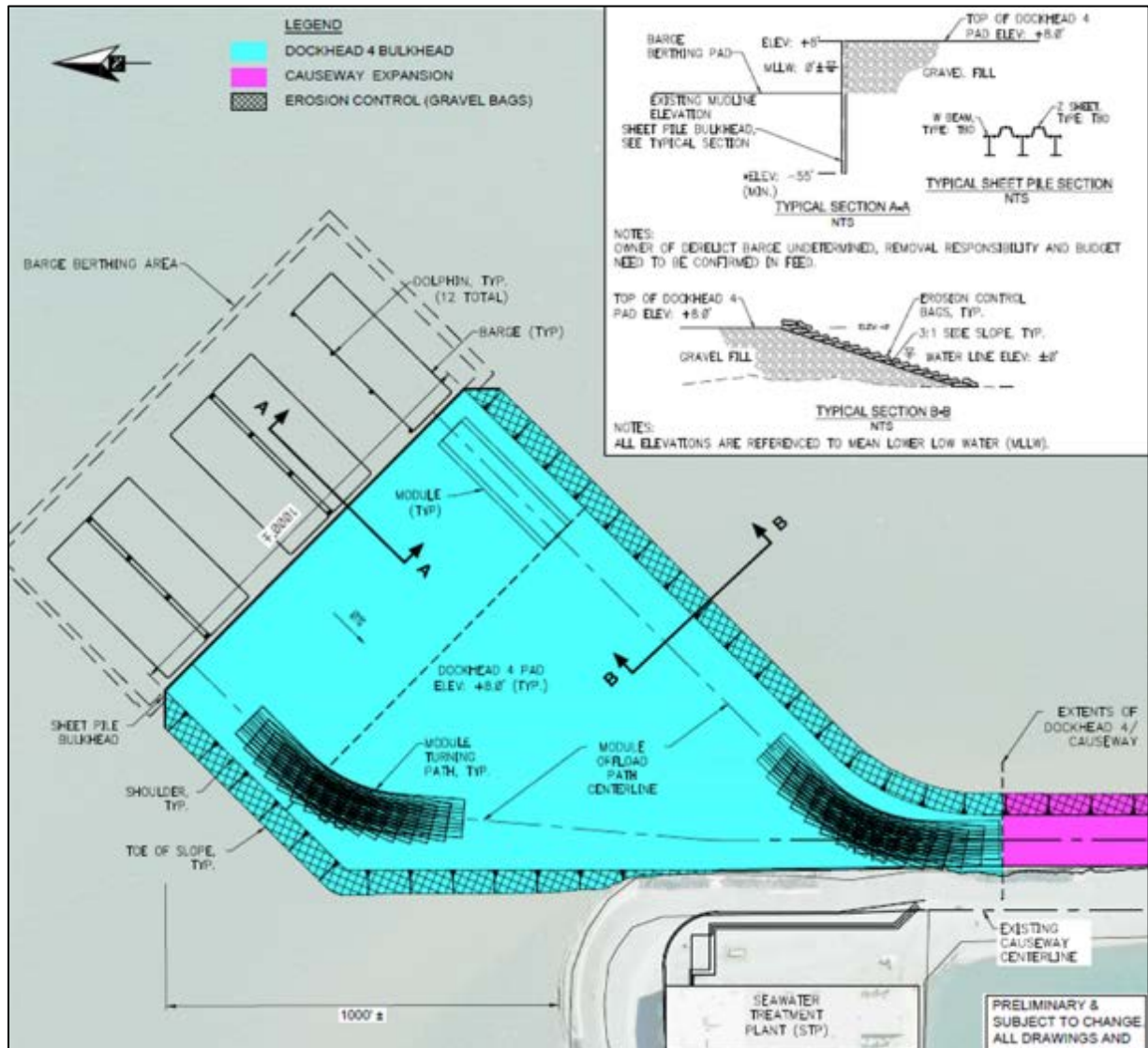


Figure 6. Plan view of the proposed Dock Head 4 in Prudhoe Bay

Pile driving crews are expected to install an average of 25 linear ft (7.6 m) of combi-wall (sheet pile and connecting 11.5-in H piles) per shift, with the hammers operating approximately 40 percent of the 12-hour shift. The H piles will be installed using an impact hammer, averaging approximately 26 piles per day, and 1,000 strikes per pile. The 25-in sheet piles will be installed using a vibratory hammer, averaging 12 piles per day, and taking approximately 24 minutes per pile. These averages include contingencies for weather, equipment, work flow, and other factors that affect the number of piles per day; therefore, these averages are assumed to be a maximum anticipated per day. DH4 will be constructed in June–October (open water season), with the hauling and placing of the gravel taking place first. Installation of the combi-wall is planned for mid-September–October (after the Nuiqsut fall whaling season and before ice). A contingency time period for combi-wall installation is late February through April of the following year working off the ice, if the originally scheduled time period becomes infeasible due to unexpected logistical or other constraints.

Twelve mooring dolphins will be installed in the cargo berths at the proposed DH4 dock head to hold the ballasted barges in place. Locations of the proposed mooring dolphins are indicated in Figure 6. Impact pile driving will be used to install these mooring dolphins (Table 4). Each mooring dolphin consists of one 48-in-diameter (1.2-m), 100-ft (30.5-m) long pile that will be driven to a minimum of 65 ft (19.8 m) into the seabed. The mooring dolphins will be installed at a rate averaging 1.25 piles per day and approximately 1,000 strikes per pile.

Four temporary spuds (14-in steel H piles) will be installed for support prior to the construction of each mooring dolphin and will be extracted immediately after completion of the dolphin. A vibratory hammer will be used for both installation and extraction of these temporary spuds. It is expected to take 1 hour to install the four spuds for a single mooring dolphin and 1 hour to extract them. We assume four spuds will be installed and extracted per day.

Installation of the mooring dolphins is planned for September–October (after the Nuiqsut fall whaling season and before ice up). A contingency time period for dolphin installation is late February thru April of the following year working off the ice, if the originally scheduled time period becomes infeasible due to unexpected logistical or other constraints.

Berthing Basin

The proposed location of the DH4 bulkhead is approximately 1,000 ft (305 m) beyond the end of the existing causeway at the STP. This location was selected as it provides an existing nominal water depth of -12 ft (-3.7 m) mean lower low water (MLLW) across the length of the bulkhead, allowing for berthing of cargo barges at their intended transit draft of 10 ft (3.05 m) without the exchange of ballast water. It also provides a nominal 2 ft (0.6 m) under keel clearance; therefore, no dredging is required for construction or use of the proposed DH4.

Screeding will be conducted over the seafloor within the berthing area to a depth of -12 ft (-3.7 m) MLLW to ensure a smooth seafloor for grounding the barges. The berthing area encompasses approximately 13.7 acres (0.06 km²). In the screeding process, a tug and/or barge pushes or drags a beam or blade across the seafloor, removing high spots and filling local depressions in the seabed without the need for excavation or disposal of seabed materials. The screeding process will redistribute the seabed materials to provide a flat and even surface on which the module cargo barges can be grounded. The screeding operation is not intended to increase or decrease overall seabed elevation so there will be no excavated materials requiring disposal.

Screeding will be performed in the summer immediately prior to each sealift and as soon as sea ice conditions allow mobilization of the screeding barge. Based on historical ice data, screeding is anticipated to be conducted during July for a period of up to 14 days. A multi-beam hydrographic survey will be performed to identify high and low spots in the seabed prior to each season. The survey will be conducted with equipment emitting sound above 200 kiloHertz (kHz) to avoid marine mammal sound exposures.

Barge Bridge

The existing bridge over the aforementioned 650-ft (198-m) breach in the causeway is too narrow for module transport and incapable of supporting the weight of the project modules. A

temporary barge bridge will therefore be constructed to accommodate transport of the modules over the breach and to the onshore road system (Figure 7). The barge bridge will be installed annually each sealift year, at the beginning of the open-water season, and will be removed each fall prior to freeze-up. The approach abutments will be constructed and mooring dolphins will be installed in the first season, and the seabed will be prepared before installation of the barge bridge for the first sealift. Some seabed preparation is expected to be required prior to installation and use of the barge bridge in each subsequent sealift year.

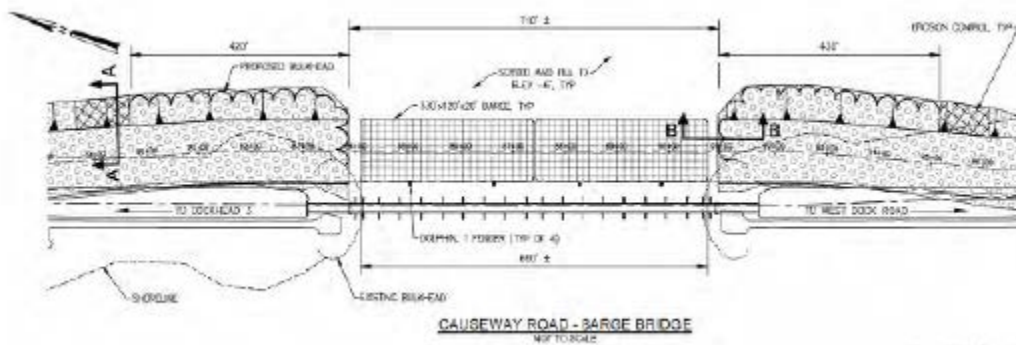


Figure 7. Proposed temporary barge bridge in Prudhoe Bay

Barge Bridge Abutments

Approach abutments will be constructed along the east side of the existing causeway on both ends of the barge bridge. These abutments will be constructed of gravel filled open-cell sheet-piled bulkheads with gravel bags for erosion control where there is no bulkhead. The bulkheads will be approximately 420 ft (128 m) long (along the causeway) and 120 ft (36.6 m) across (Figure 7). Gravel quantities required for construction of the abutments are included in the quantities provided in Table 2; south abutment included in Causeway Section 1 and north abutment in Section 2. Surface area impacts are included in the estimates for the causeway widening (Table 2). The numbers and types of pilings to be installed for the bulkhead are provided in Table 5.

Table 5. Piles to be installed for the bulkhead of the barge bridge abutments

DH4 Component	Part	Piles (number by hammer type)		
		Vibratory Hammer	Impact Hammer	All
		Sheet Pile ^a	14-in H Pile ^b	
South Abutment	Dock face ^a	429	--	429
	Tail wall ^b	540	18	558
	Total	969	18	987
North Abutment	Dock face ^a	389	--	389
	Tail wall ^b	448	13	461
	Total	837	13	850
Total	--	1,806	31	1,837

^a Steel sheet piles expected to be PS27.5 Type with width of 19.69 in each, length of 63 ft, and estimated embedment depth of 43 ft.

^b H piles expected to be HP 14 x 89 type steel H piles with width of 14 in each, length of 63 ft, and embedment depth of 43 ft;

Much of the abutment sheet pile is for the tail walls that run back from the bulkhead into the gravel fill and terminate at an anchor pile (H pile). A large portion of this tail wall piling and many of the tail wall anchor piles (H piles) will be located above MLLW and will therefore be driven into dry ground and are not included in the analysis for assessing in-water noise impacts on marine mammals. The numbers and types of piles that will be driven into Prudhoe Bay waters below MLLW for the barge bridge abutments are indicated in Table 6.

Table 6. Piles to be installed below MLLW for the proposed barge bridge abutments

Barge Bridge	Component	Pile Type / Size	Method	Total Piles	Piles / Day	Duration / Pile (strikes or minutes)	Work Days ^b
South Abutment	Dock face	14-in H pile ^c	Impact	--	--	--	--
		19.69-in sheet pile ^a	Vibratory	350	16	18.9	23
	Tail wall	14-in H pile ^c	Impact	4	22	1,000	1
		19.69-in sheet pile ^a	Vibratory	345	16	18.9	23
	Total	NA	NA	699	NA	NA	47
North Abutment	Dock face	14-in H pile ^c	Impact	--	--	--	--
		19.69-in sheet pile ^a	Vibratory	353	16	18.9	24
	Tail wall	14-in H pile ^c	Impact	4	22	1,000	1
		19.69-in sheet pile ^a	Vibratory	256	16	18.9	17
	Total	NA	NA	613	NA	NA	42
Total	All	NA	NA	1,312	NA	NA	89

^a Steel sheet piles expected to be PS27.5 Type with width of 19.69 in each, and length of 63 ft, and embedment depth of 43 ft; total linear (horizontal) length of the 1,304 sheet piles is 2,139.6 ft.

^b Days is the number of calendar days on which pile driving of sheet piles will occur based on a rate of 25 linear (horizontal) ft of sheet piles per day rounded up to whole day.

^c Steel H piles expected to be HP 14x89 type H piles with width of 14 in each, length of 40 ft; total linear (horizontal) length of the 8 H piles is 9.3 ft.

Two types of hammers will be used for pile driving: vibratory pile driving will be used to install the sheet pile (dock face and tail walls) for the new bulkhead, and impact hammers will be used to install the associated tail wall anchor piles. Sheet piles will be installed from land or barges on open water, and potentially from the ice if the schedule is altered. Pile driving crews typically install an average of approximately 25 linear (horizontal) feet (7.62 m) of abutment (sheet pile and H pile) per shift, depending on weather, substrate, and equipment, with the hammers operating approximately 40 percent of the time. The 19.69-in sheet piles will be installed using a vibratory hammer, averaging 15.24 piles per day taking approximately 19 minutes per pile. These averages include contingencies for weather, equipment, work flow, and other factors that affect the number of piles per day; therefore, these averages are assumed to be a maximum anticipated per day.

Construction of the barge bridge abutments is scheduled for July–August with no pile-driving to be conducted during the Nuiqsut whaling season (August 25–September 15). A contingency time period for installation is late February thru April of the following year working off the ice, if the originally scheduled time period becomes infeasible due to unexpected logistical or other constraints.

Barge Bridge Mooring Dolphins

Four mooring dolphins (Table 7) will be installed at the barge bridge site to protect the current bridge from the barges and hold the ballasted barges in place. Each mooring dolphin consists of one 48 in-diameter (1.2-m), 100-ft (30.5-m) long steel pipe pile that will be driven with an impact hammer to a minimum of 65 ft (19.8 m) into the seabed. These 48-in piles are expected to be driven to depth at a rate of 1.25 piles/day with an estimated 1,000 strikes required per pile.

As described above for the DH4 mooring dolphins, 4 temporary spuds (14.5-in steel H piles) will be installed for support prior to the construction of each barge bridge mooring dolphin (Table 7) and will be extracted immediately after completion of the dolphin. A vibratory hammer will be used for both installation and extraction. It is expected to take 1 hour to install the four spuds for a single mooring dolphin and 1 hour to extract them. We assume four spuds will be installed and extracted per day.

Table 7. Piles to be installed for the proposed barge bridge mooring dolphins

Barge Bridge Component	Pile Type / Size	Method	Total Piles	Piles / Day	Duration / Pile (strikes or minutes)	Work Days ^{c,e}
Mooring Dolphins	48-in pipe pile ^{a,b,c}	Impact	4	1.25	1,000	4
Mooring Dolphins	14-in H pile (temp) ^{a,d,e}	Vibratory	16	4	13.4	4
Total	NA	NA	20	NA	NA	8

Barge Bridge Component	Pile Type / Size	Method	Total Piles	Piles / Day	Duration / Pile (strikes or minutes)	Work Days ^{c,e}
<p>^a All piles are steel.</p> <p>^b Mooring dolphin are expected to be (1) 48-in steel round pipe pile each, with a length of 100 ft, and estimated embedment depth of 65 ft. Total linear (horizontal) length of the 4 piles is 16 ft.</p> <p>^c Days is the number of calendar days on which pile driving of the 48-in piles will be expected to occur (total days) based on a production rate of 1.25 piles per day rounded up to whole day; actual duration will be dependent on weather, substrate, and equipment.</p> <p>^d Temporary spud piles used for support during installation of mooring dolphins, are assumed to be steel H piles, 14 in wide and 30 ft long, 4 per mooring dolphin. They will be installed with a vibratory hammer and extracted with a vibratory hammer after each mooring dolphin is installed.</p> <p>^e Days is the number of calendar days on which pile driving of the temporary spud pile will occur; they are installed with vibratory hammer, then removed with vibratory hammer after mooring dolphin is installed; it takes 1 hour to install four spuds and 1 hour to extract them; however with the hiatus between installation and extraction (for installing the mooring dolphin 48-in pile) we assume a rate of 4 spuds per day.</p>						

Construction of the barge bridge abutments, including installation of the mooring dolphins, is scheduled for July-August, with no pile-driving to be conducted during the Nuiqsut fall whaling season (August 25–September 15). The contingency time period (if not completed as scheduled) for dolphin installation is late February thru April of the following year, working off of ice.

Seabed Preparation at the Barge Bridge

At the beginning of each sealift season, bridge barges will be positioned in the breach and ballasted to a prepared pad surface to form a bridge. A level and stable barge pad must be constructed to support the ballasted barges at the proper horizontal and vertical location for successful transit of modules across the breach. The pad will be designed to support the fully loaded weight of the barge and the heaviest modules.

Pad construction will include an initial through-ice bathymetric survey within the breach. This through-ice survey will be conducted by drilling or augering holes through the ice and measuring the bottom elevations by a survey rod tied to the local Global Positioning System - Real Time Kinematic system to provide the needed level of accuracy of horizontal positions and vertical elevations. A grid of survey holes will be established over the 710-ft (216-m) by 160-ft (48.8-m) dimensions (2.6 acres; 0.01 km²) of the breach barge pad to allow for determination of the bottom bathymetry such that a plan can be developed accordingly to prepare the barge pad surface.

Seabed preparation will consist of smoothing the seabed within the pad area as necessary to level the seabed across the pad at an elevation grade of approximately -7 ft (-2.1 m) MLLW. Some gravel fill may be required at scour holes. The primary source of gravel will be a new (proposed) onshore mine located southwest of the GTP plant site and just north of the Putuligayuk River. Trucks will be loaded at the mine with gravel and driven to the site for stockpiling and/or placement with loaders and excavators. Rock filled marine mattresses or gabions approximately 1 ft (0.3 m) thick will then be placed across the graded pad to provide a stable and low maintenance surface at -6 ft (-1.8 m) MLLW on which the barges will be grounded. These

mattresses are gravel filled containers constructed of high-strength geogrid, with the geogrid panels laced together to form mattress-shaped baskets.

The seabed preparations will be performed through the ice during winter using excavation equipment and ice excavation methods. Equipment required for the grading work includes ice trenchers, excavators, front end loaders, man-lifts, haul trucks, survey equipment, and other ancillary equipment necessary to support the operation. An equipment spread is considered to include a trencher for cutting ice, an excavator for removing ice, a second excavator, and haul units. Through-ice grading efforts will be initiated by cutting through the ice with trenchers. Excavators will then proceed to remove the ice to expose the seafloor bottom. Once a section has been exposed to the seafloor, the bottom will be graded to -7 ft (-2.1 m) MLLW using the excavation equipment. Marine mattresses will then be installed on the graded pad, likely requiring use of a crane. Grounded ice conditions are expected to occur at the breach on or before February 1st of each year at the latest. Through-ice surveying and grading work will be expected to begin immediately after, if not sooner. Total construction duration is estimated at between 45 and 60 days with construction being complete by end of March and demobilization from the breach area in early April.

There will potentially be some smoothing (screeding) right before the barges are placed in summer in an effort to achieve a surface that is near flush with adjacent subsurface elevations. Any screeding at the barge bridge site will be expected to take 14 days or less.

Barge Bridge Installation

The first two barges to offload will be used to form the temporary bridge, paralleling the existing weight-limited bridge, and spanning the breach. These barges will be moved into place against the mooring dolphins with tugs where they will be ballasted and fastened to the causeway abutments and each other. The two ballasted barges will be placed bow-to-bow when resting on the seafloor. The barge rakes will angle upward and touch at their adjoining point, leaving an approximately 52.5-ft (16-m) gap at the seafloor between the barges. The stern of each barge will angle sharply upward at each end of the bridge, leaving an additional 10-ft (3.1-m) gap at the seafloor at each end.

Ramps will be installed to accommodate smooth transit of the self-propelled module transporters (SPMTs) over the bridge. Modules will be transported by SPMTs down the causeway and over the temporary bridge to a staging pad at the base of West Dock. From there, they will be moved southward over approximately 6 miles (9.7 km) of new and existing roads to the GTP construction site.

Construction of the temporary barge bridge is expected to take 3 days. The temporary bridge will be held in place by the mooring dolphins. The temporary bridge is expected to be in place for 21 to 39 days, depending on weather conditions and logistics. At the conclusion of each year's sealift, the barges will be de-ballasted, and removed from the breach. Upon the subsequent summer season and the next sealift, the barges will be positioned back in the breach and re-ballasted onto the barge pad for module transport operations.

West Dock modifications will be left in place after modules are offloaded, as their removal will

result in greater disturbance to the surrounding environment. The piling and infrastructure forming the offshoot and ramp to the temporary barge bridge will be left in place rather than pulling it out as this may result in erosion or weakening of the existing causeway. Mooring pilings will be cut below the sediment surface and removed, and then covered with surrounding sediment.

2.1.1.2 On-land Activities

Other facilities that will be built on land are outlined below.

Water Reservoir

- new freshwater reservoir constructed to supply water to the GTP, including pump facilities and a transfer pipeline between the reservoir and the GTP

Gravel mine

- new gravel mine to supply granular fill for roads, pads, West Dock Causeway widening and expansion, staging areas, existing roads and pads, and augmentation and maintenance of pads and roads during operation

Prudhoe Bay Unit Gas Transmission Line (PBTL)

- 1-mile-long, 60-in-diameter pipeline to transport natural gas from the existing PBU Central Gas Facility (CGF) to the GTP
- new meter station

Point Thomson Unit Gas Transmission Line (PTTL)

- 62.5-mile-long, 32-in-diameter pipeline to transport natural gas from the Point Thomson Unit (PTU) to the GTP
- aboveground facilities, including a meter station, pig launcher/receivers, and three mainline valves (MLVs)

Access roads and staging area

- four permanent gravel access roads to connect the GTP with other Gas Treatment Facilities
- temporary ice roads and pads used during construction
- 52 ice roads and ice pads for temporary access along the PTTL
- module staging area

Pioneer camp

- temporary construction camp to house workers as well as materials to commence construction

Associated Transfer Pipelines

- 1.8-mile fuel gas pipeline from the PBU CGF to the GTP and GTP operations camp
- 0.6-mile propane pipeline from the PBU CGF to the GTP
- 1.1-mile Putuligayuk River pipeline from the Putuligayuk River to the reservoir
- 5-mile supply water pipeline from the reservoir to the GTP and GTP operations camp

2.1.1.3 Cook Inlet

AGDC proposes to construct facilities to transport and offload LNG in Cook Inlet for export, including a Marine Terminal and the Mainline crossing of Cook Inlet (Figure 8). The Marine Terminal consists of a permanent Product Loading Facility (PLF) and a temporary Material Offloading Facility (MOF). The Mainline crossing includes the installation of the 42-in-diameter natural gas pipeline across the inlet and construction of a Mainline MOF. Brief descriptions of these proposed facilities are provided below. Table 8 provides a project schedule for Cook Inlet activities. AGDC will perform a sound source verification (SSV) at the beginning of the pile driving to characterize the sound levels associated with different pile and hammer types, as well as to establish the marine mammal monitoring and mitigation zones.

Table 8. Project schedule for Cook Inlet activities (Q=1/4 of calendar year)

Construction Activity	Start Date	End Date
Marine Terminal & Mainline MOF		
Site Preparation Activities, Temporary MOF Construction	1Q 2021	2Q 2022
Dredging, Complete Temporary MOF, Construct Mainline MOF	1Q 2022	2Q 2022
Commence Installation of Trestle and Berths, Quadropod Installation	1Q 2023	4Q 2023
Complete Installation of Trestle, Continue Installation of Berths, Commence Installation of PLF Modules, Berths, and Mooring Dolphins	1Q 2024	4Q 2024
Complete Installation of PLF	1Q 2025	4Q 2025
MOF Reclamation/Demobilization	3Q 2027	3Q 2028
Mainline Offshore Cook Inlet Spread		
Construct Shore Crossings and Nearshore Pipeline	2Q 2023	4Q 2023
Complete Offshore Pipeline Construction, Hydrottest, and Final Tie-In	2Q 2024	3Q 2024

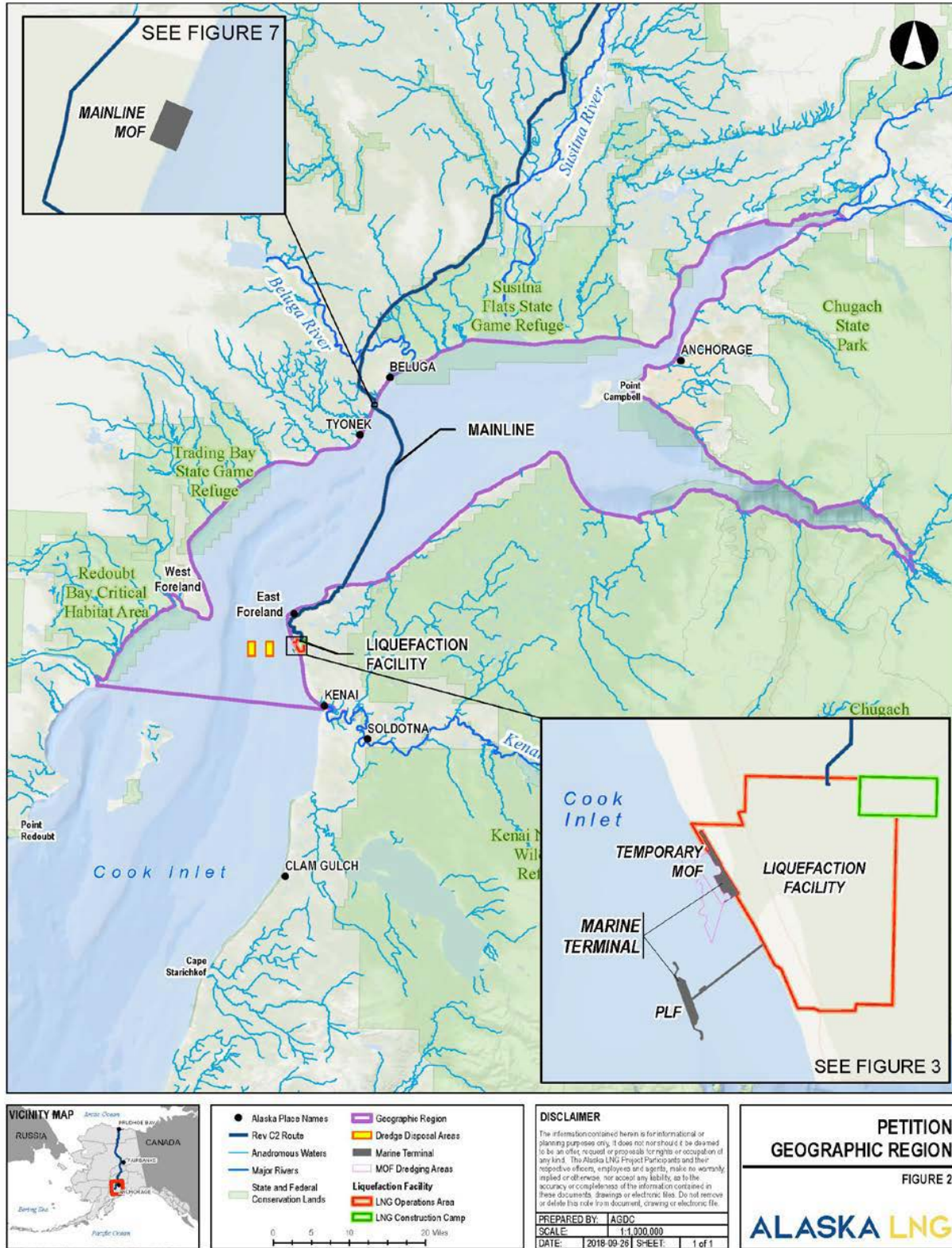


Figure 8. Location of proposed activities in Cook Inlet

Mainline Material Offloading Facility (Mainline MOF)

A Mainline MOF is proposed to be constructed on the west side of Cook Inlet near the existing Beluga Landing to support installation of the Cook Inlet shoreline crossing and onshore construction. The Mainline MOF will be located near the existing Beluga Landing, however, use of the existing landing is not considered to be feasible.

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

- Lift-on/Lift-off (Lo-Lo) Berth for unloading pipes and construction materials;
- Roll-on/Roll-off (Ro-Ro) Berth and ramp dedicated to Ro-Ro operations.

The quay will be 450 ft long (along the shoreline) and 310 ft wide (extending into the Cook Inlet). A Ro-Ro ramp (approximately 80 ft by 120 ft) will be constructed adjacent to the quay. Both the quay and the Ro-Ro ramp will consist of anchored sheet pile walls backed by granular fill (Table 9). The sources for the granular material will be onshore. Surfacing on the quay will be crushed rock. Some fill material for the quay and Ro-Ro ramp are expected to be generated by excavation of the access road. Any additional needed fill materials and crushed rock for surfacing will be barged in.

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

Approximately 1,270 ft of sheet pile will be installed for construction of the quay and Ro-Ro ramp, and a corresponding length of sheet pile will be installed as anchor wall. Roughly half (670 ft) of the total amount of sheet pile will be installed in the waters of Cook Inlet, while the remainder will be installed as anchor wall in fill material, or in the intertidal area when the tide is out.

The Mainline MOF will be constructed in a single construction season. A break-down of activities per project Year is provided in Table 9 below. Crews are expected to work 12 hours per day, six days per week. The sheet pile will be installed using marine equipment, with the first 50 percent of embedment conducted using a vibratory hammer and the remaining 50 percent conducted using an impact hammer. Hammers are expected to be operated either 25 percent of a 12-hour construction day (impact hammer) or 40 percent of a 12-hour construction day (vibratory hammer).

Table 9. Structures to be installed in Cook Inlet as part of Mainline MOF construction

Year	Structure Type	Structures	Sheet Pile (ft)	Pipe Pile (number)	Hammer	Method	Days ^a	Months ^b
2	quay ^c	1	470	-	Vibratory/Impact ^e	Marine	10	Apr-May
2	Ro-Ro ramp ^c	1	200	-	Vibratory/Impact ^e	Marine	4	Apr-May
All	-	2^c	670^d	-	Vibratory/Impact^e	Marine	14	Apr-May

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

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

^c The quay and the Ro-Ro ramp are adjoining parts of the Mainline MOF.

^d Itemized sheet pile is for only sheet pile installed in the water; additional sheet pile would be installed in the dry (600 ft, in intertidal area when tide is out) and additional sheet pile installed in fill as anchor wall.

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

Mainline Pipeline Cook Inlet Crossing

The proposed Mainline, a 42-in-diameter, natural gas pipeline, will cross the Cook Inlet (Figure 9) shoreline on the west side of the inlet (north landfall) south of Beluga Landing at pipeline milepost (MP) 766.3, traverse Cook Inlet in a generally southward direction for approximately 26.7 miles, and cross the east Cook Inlet shoreline near Suneva Lake at milepost (MP) 793.1 (south landfall). The pipe will be trenched into the seafloor and buried from the shoreline out to a water depth of approximately 35–45 ft below MLLW on both sides of the inlet, approximately 8,800 ft from the north landfall and 6,600 ft from the south landfall. Burial depth (depth of top of pipe below the seafloor) in these areas will be 3–6 ft. Seaward of these sections, the concrete coated pipeline will be placed on the seafloor. The area of seafloor that will be directly affected by construction and operation of the Cook Inlet crossing of the Mainline is specified in Table 10. Additional footprint and acoustic impact will result from the use of anchors to hold the pipelay vessel in place while installing the pipeline on the seafloor, this will require dynamic positioning.

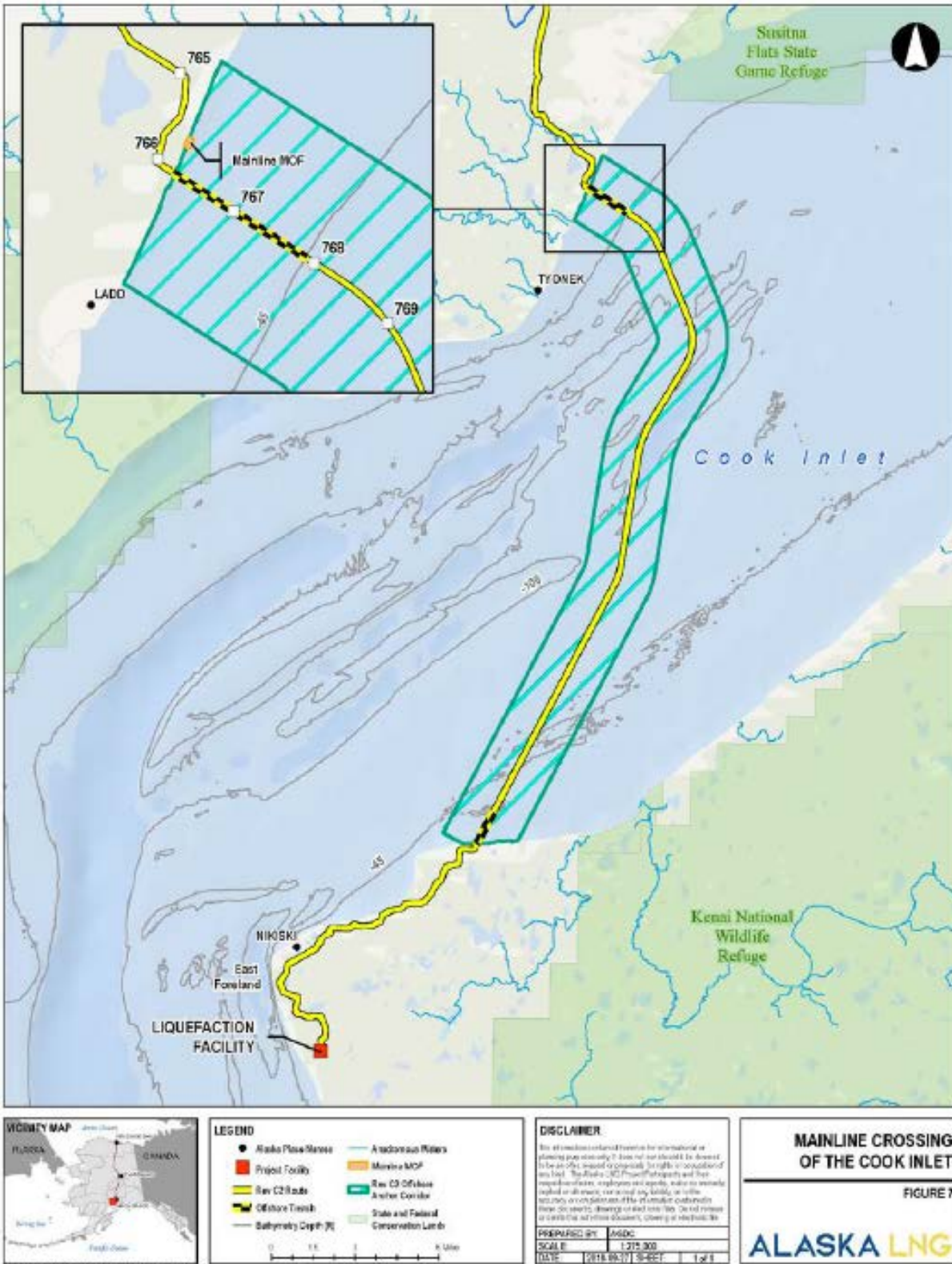


Figure 9. Mainline crossing of Cook Inlet

Table 10. Area of Cook Inlet seafloor directly affected by the mainline crossing

Facility/Activity	Affected during Construction (acres) ^a
Nearshore trenching	27 – 52 acres / 10.9 – 20.2 hectares
Offshore pipe installation	11 acres / 4.5 hectares
Total	40 acres / 16.2 hectares

^aAdditional seafloor impacts will occur from anchoring of the pull barge and pipelay vessel.

Pipeline Pre-installation Surveys

Geophysical surveys would be conducted just prior to pipeline construction. A detailed bathymetric profile (longitudinal and cross) would be conducted. Types of geophysical equipment expected to be used for the surveys would include (Table 11):

- Single-beam echosounder planned for use during this program operate at frequencies greater than 200 kHz.
- Multi-beam echo sounders planned for this program operate at frequencies greater than 200 kHz.
- Side-scan sonar system planned for use during this program operate at a frequency above 400 kHz.
- Magnetometer, which is an instrument that does not emit underwater sound.

Acoustic characteristics of equipment expected to be used are provided in Table 11.

Table 11. Acoustical characteristics of planned geophysical and geotechnical equipment

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

^aA similar model may be used.

^bSource: Manufacturer brochure.

^crms = root mean square.

^dShores 2013

Trenching, Pipelay, and Burial

The pipeline would be trenched and buried in the nearshore portions of the route across Cook Inlet. Dimensions of the trenches are provided in Table 12 and Table 13.

Table 12. Expected volumes to be excavated from subsea pipe trenches in Cook Inlet

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

Table 13. Expected seafloor area directly affected by trenching for Cook Inlet crossing

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

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

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

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

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

Offshore Pipeline Installation

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

The pipeline crossing of Cook Inlet would occur over two consecutive construction seasons from April 1 through October 31. Work from the pipelay vessel and pull barge would be conducted 24 hours per day, 7 days per week, until the work planned for that season is completed. Anchor handling durations were estimated differently for the two construction seasons because operations are different in each year. In Year 3, pipeline construction will be closer to shore, the vessel will be stationed for longer periods of time to excavate the trench, winch/laydown, and weld pipeline. In Year 4, there is no trenching, therefore, the vessel will require anchor handling more frequently. Anchor handling is expected to be conducted 25 percent of the time that the pull barge is on site in Year 3. The estimate for anchor handling duration in Year 4 was based on the proposed route length, the total numbers of individual anchor moves (Table 14), and the estimated time required to retrieve and reset each anchor (approximately 30 minutes per anchor to retrieve and reset). A breakdown of activities per season is provided below.

Pipeline construction Year 3

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

Pipeline construction Year 4

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

- Anchor handling is estimated to occur over 13 24-hour periods in Year 4
- Tie-in the offshore section to the buried nearshore sections on both sides of the Cook Inlet.
- Flood, hydrotest, and dry the Mainline pipeline within Cook Inlet

Table 14. Anchors to be handled during installation of the offshore portion of mainline crossing

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

Marine Terminal - Nikiski

The proposed Marine Terminal will be constructed adjacent to the proposed onshore LNG Plant near Nikiski, Alaska, (Figure 8) and will allow LNG carriers (LNGCs) to dock and be loaded with LNG for export. Primary components of the Marine Terminal include a PLF (Figure 10) and the Temporary MOF (Figure 10).

Product Loading Facility (PLF)

The proposed PLF will be a permanent facility used to load LNG carriers (LNGCs) for export. It consists of two loading platforms, two berths, a Marine Operations Platform, and an access trestle that supports the piping that delivers LNG from shore to LNGCs and includes all the equipment to dock LNGCs. Analyzed elements of the PLF are shown in Figure 10 and Figure 11, and are described as follows.

- **PLF Loading Platforms** – Two loading platforms, one located at either end of the north-south portion of the trestle, will support the loading arm package, a gangway, supporting piping, cabling, and equipment. The platforms will be supported above the seafloor on steel-jacketed structures called quadropods;
- **PLF Berths** – Two berths will be located in natural water depths greater than -53 ft MLLW and will be approximately 1,600 ft apart at opposite ends of the north-south portion of the trestle. Each berth will have four concrete pre-cast breasting dolphins and six concrete pre-cast mooring dolphins. The mooring and breasting dolphins will be used to secure vessels alongside the berth for cargo loading operations. The mooring and breasting dolphins will be supported over the seabed on quadropods. A catwalk, supported on two-pile bents, will connect the mooring dolphins to the loading platforms;
- **Marine Operations Platform** – A Marine Operations Platform will be located along the east-west portion of the access trestle and will support the proposed Marine Terminal Building, an electrical substation, piping, cabling, and other equipment used to monitor the loading operations. The platform will be supported above the seafloor on four-pile bents;
- **Access Trestle** – This structure is T-shaped with a long east-west oriented section and a shorter north-south oriented section and carries pipe rack, roadway, and walkway. The

pipe rack contains LNG loading system pipelines, a fire water pipeline, utility lines, power and instrument cables, and lighting. The east-west portion of the trestle extends from shore, seaward, for a distance of approximately 3,650 ft and will be supported on three-pile and four-pile bents at 120-foot intervals. The north-south oriented portion of the access trestle is approximately 1,560 ft long, and is supported on five-pile quadropods.

Construction of the PLF and berths will be both overhead construction (conducted with equipment located on a cantilever bridge extending from shore) and marine construction (conducted with equipment located on barges/vessel). The footprint of the PLF is approximately 18.67 acres; however, a much smaller footprint of seafloor within this area will actually be impacted by the bents and quadropods supporting the PLF.

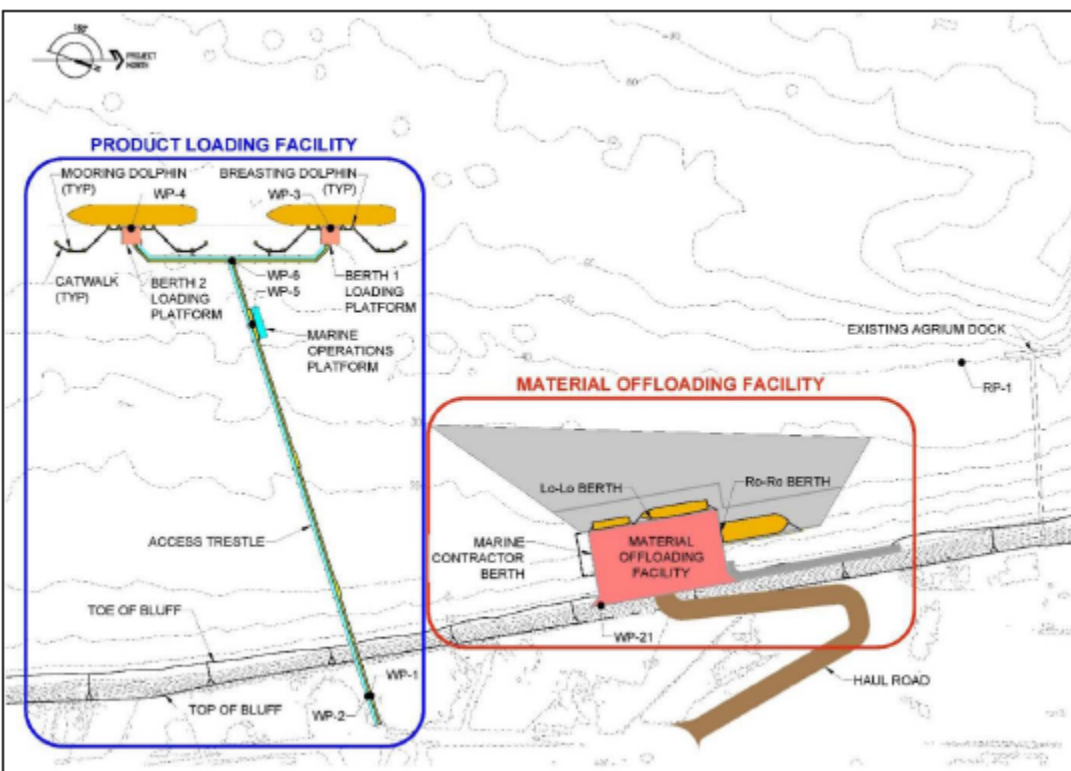


Figure 10. Product Loading Facility and Material Offloading Facility, near Nikiski

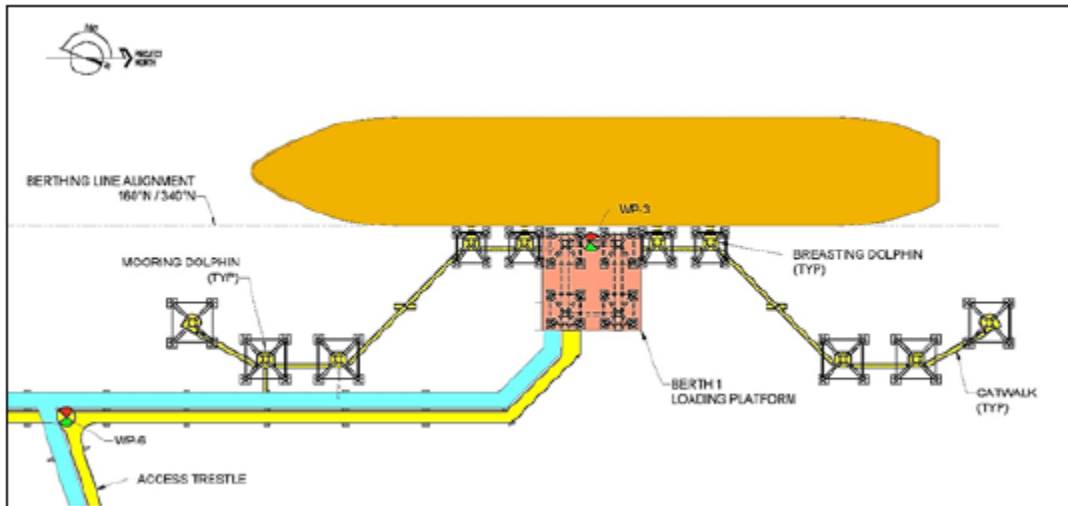


Figure 11. Berth layout at Product Loading Facility near Nikiski

The PLF will be constructed over the course of four ice-free seasons (Years 2–5); however, Year 2 activities associated with PLF construction will include only installation of onshore portions of the PLF, with no impacts to ESA-listed marine mammals or critical habitat expected. Activities in Years 3 through 5 are described below.

PLF Year 3 Construction

In Year 3, marine construction will be mobilized, and the cantilever bridge will be commissioned. A total of 35 bents and quadropod structures will be installed for part of the east-west access trestle, and eight quadropods will be installed to support the berth loading platforms (Table 15).

Table 15. Pile structures to be installed for the PLF in Year 3

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ^d	Months
			48-in Piles	60-in Piles				
E-W Trestle	3-pile bent ^a	11	-	33	Impact ^b	Overhead	22	Apr–Jun
E-W Trestle	4-pile bent	10	-	40	Impact ^c	Overhead	20	Jun–Aug
Berth 1	quadropod	4	20	-	Impact ^c	Marine	8	Apr–May
Berth 2	quadropod	4	20	-	Impact ^c	Marine	8	Apr–May
N-S Trestle	quadropod	8	40	-	Impact ^c	Marine	16	May–Jun
Total	--	35	80	63	--	--	74	Apr–Aug

^a Four 3-pile bents (12 piles) to be installed on land in Year 2; five additional three-pile bents for the E-W access trestle will be installed on land or in the dry within the intertidal zone in Year 3.

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

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ^d	Months
			48-in Piles	60-in Piles				
^c One impact hammer is expected to be used from the overhead cantilever bridge. ^d Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure, pile driving would occur during only a portion of each day. Notes: E-W = east-west N-S = north-south								

PLF Year 4 Construction

In Year 4, the remainder of the bents for the east-west access trestle will be installed. Additionally, bents supporting the Marine Operations Platform and north-south trestle will be installed. A total of 26 bent and quadropod structures will be installed (Table 16).

Table 16. Pile structures to be installed for the PLF in Year 4

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ^c	Month(s)
			48-in	60-in				
E-W Trestle	4-pile bent	7	-	28	Impact ^a	Overhead	14	Apr–May
Operations Platform	4-pile bent	3	-	12	Impact ^a	Overhead	6	May–Jun
Breasting Dolphins	quadropod	8	8	32	Impact ^b	Marine	16	Apr–May
Mooring Dolphin	quadropod	2	2	8	Impact ^b	Marine	4	May
N-S Trestle	quadropod	6	30	-	Impact ^b	Marine	12	Apr–May
Total	--	26	40	80	--	--	52	Apr–Jun

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

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

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

PLF Year 5 Construction

In Year 5, installation of the mooring quadropods will be completed and the bents supporting the catwalk between the loadout platforms and the mooring dolphins will be installed. A total of 18 bent and quadropod structures will be installed (Table 17).

Table 17. Pile structures to be installed for the PLF in Year 5

PLF Element	Structure Type	Number of Structures	Number of Piles		Hammer	Method	Days ^b	Month(s)
			48-in	60-in				
Mooring Dolphin	quadropod	10	10	40	Impact ^a	Marine	20	Apr–Jun
Catwalk	2-pile bent	4	-	8	Impact ^a	Marine	16	Apr–May
Total	--	18	10	48	--	--	36	Apr–Jun

^aTwo impact hammers are expected to be used from the barges.

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

All PLF bents and quadropods are expected to be installed with impact hammers. The anticipated production rate for installation of the bents is one bent per six construction days, and for quadropods it is one quadropod per eight work days. Pile driving is expected to occur during only two of the six days for bents and two of the eight days for quadropods. It is also assumed the impact hammer will only be operated approximately 25 percent of time during the two days of pile driving.

Temporary Marine Terminal Material Offloading Facility (Marine Terminal MOF)

The proposed Marine Terminal MOF, to be located near the PLF in Nikiski (Figure 10), will be a temporary facility consisting of three berths and a quay that will be used during construction of the Liquefaction Facility to enable direct deliveries of equipment modules, bulk materials, construction equipment, and other cargo to minimize the transport of large and heavy loads over road infrastructure. The Marine Terminal MOF has been designed as a temporary facility and will be removed early in operations when it is no longer needed to support construction of the Liquefaction Facility.

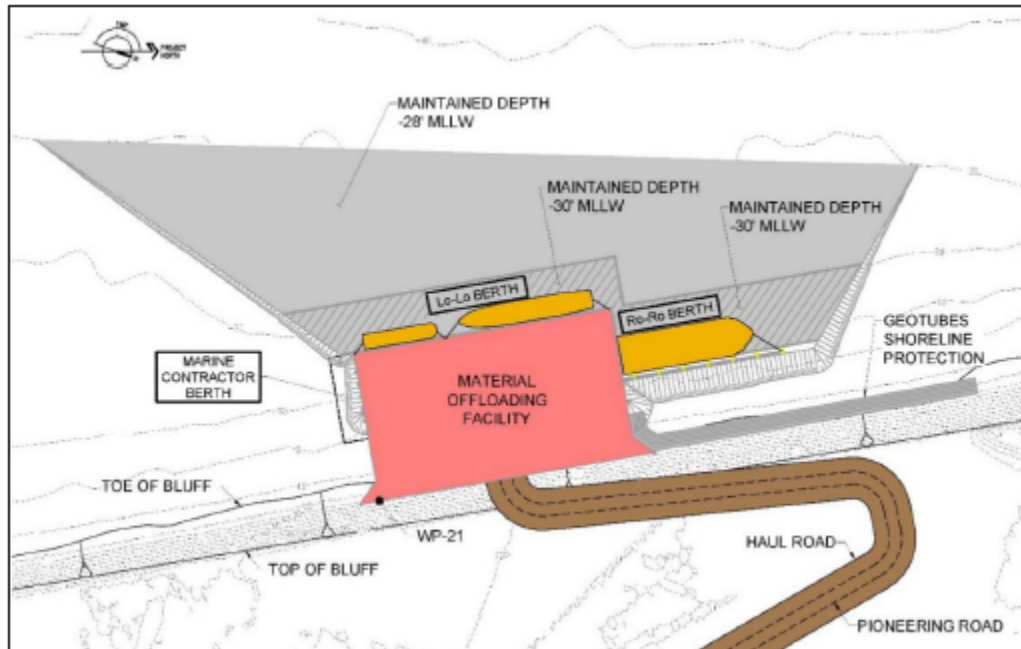


Figure 12. General arrangement of the temporary Material Offloading Facility, near Nikiski

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

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

Berths at the Marine Terminal MOF will include:

- One Lo-Lo berth with a maintained depth alongside of -32 ft MLLW;
- One Ro-Ro berth with a maintained depth alongside of -32 ft MLLW; and
- One grounded barge bed with a ground pad elevation of +10 ft MLLW.

Seafloor areas directly affected by construction of the MOF, and the associated dredging are itemized in Table 18.

Table 18. Cook Inlet seafloor affected by construction of the MOF

Facility/Activity	Affected during Construction (acres)
Temporary MOF & MOF Dredging Area	62.01
Dredge Disposal Area	1,200.00
Shoreline Protection	1.54
Total	1,263.55
Note: The temporary MOF footprint and temporary MOF dredging area overlap by 16.98 acres. Approximately 50.7 acres will be dredged. The MOF will encompass approximately 28.30 acres.	

The Marine Terminal MOF will be constructed over the course of two construction seasons (Years 1 and 2). The estimated number of sheet pile and pipe pile structures that will be installed in each season, along with the methods and durations of the installation activities, are provided in (Table 19).

The combi-wall and the first six of eleven coffer cells will be installed in Year 1. An equal amount of sheet pile anchor wall will be associated with the combi-wall, but the anchor wall will be driven into fill. Six 24-in template pipe piles will be installed with a vibratory hammer before the sheet pile is installed for each coffer cell and then removed when coffer cell installation is complete. The remaining five coffer cells and fill will be installed in Year 2, along with the quadropods for the dolphins for the Ro-Ro berth.

The Marine Terminal MOF will be constructed using both land-based (from shore and subsequently from constructed portions of the Marine Terminal MOF) and marine construction methods. The anticipated production rate for installation of combi-wall and coffer cells is 25 linear feet per day per crew, with two crews operating, and vibratory hammers operating 40 percent of each 12-hour construction day. The anticipated production rate for quadropod installation is the same as described in the “Mainline MOF” section above.

Table 19. Sheet and pile structures to be installed for the temporary MOF construction

Year	Structure Type	Number of Structures	Number of Piles			Sheet Pile (ft)	Method	Hammer	Days ^a	Months
			24-in	48-in	60-in					
1	combi-wall ^b	1	-	-	35	1,075	land	vibratory	22	Jul
1	coffer cell	6	36 ^c	-	-	2,454	land	vibratory	56	Jul-Oct
2	coffer cell	5	30 ^c	-	-	2,447	land	vibratory	54	Apr-Jun
2	quadropod ^d	7	7	28	-	-	marine	impact	14	Apr-Jun
All	-	19	73	28	35		-	-	146	Apr-Oct

^aNumber of days on which pile-driving will occur, based on expected progress rate of 2 days per structure for pile driving, 25 ft per day per crew for sheet pile and combi-wall. Pile driving will occur during only a portion of each of these days. One day is also required per structure for installation of the templates for the coffer cell (see footnote c).

^bCombi-wall is a wall made of sheet piles with pipe piles at interval along the wall for support. These piles and sheet wall are installed from land but are located in water; therefore, these components were used in Level A and B evaluation. There will also be an equal length of anchor wall with no pipe piles installed in fill, on land and therefore no underwater sound is anticipated and was not used in Level A and B evaluation.

^cThese are 24-in piles or spuds driven in the seafloor to form templates for the circular sheet pile (coffer cell); one pile driving day is added for template installation for each coffer cell.

^dEach of these quadropods for the MOF Ro-Ro dolphins consists of five piles.

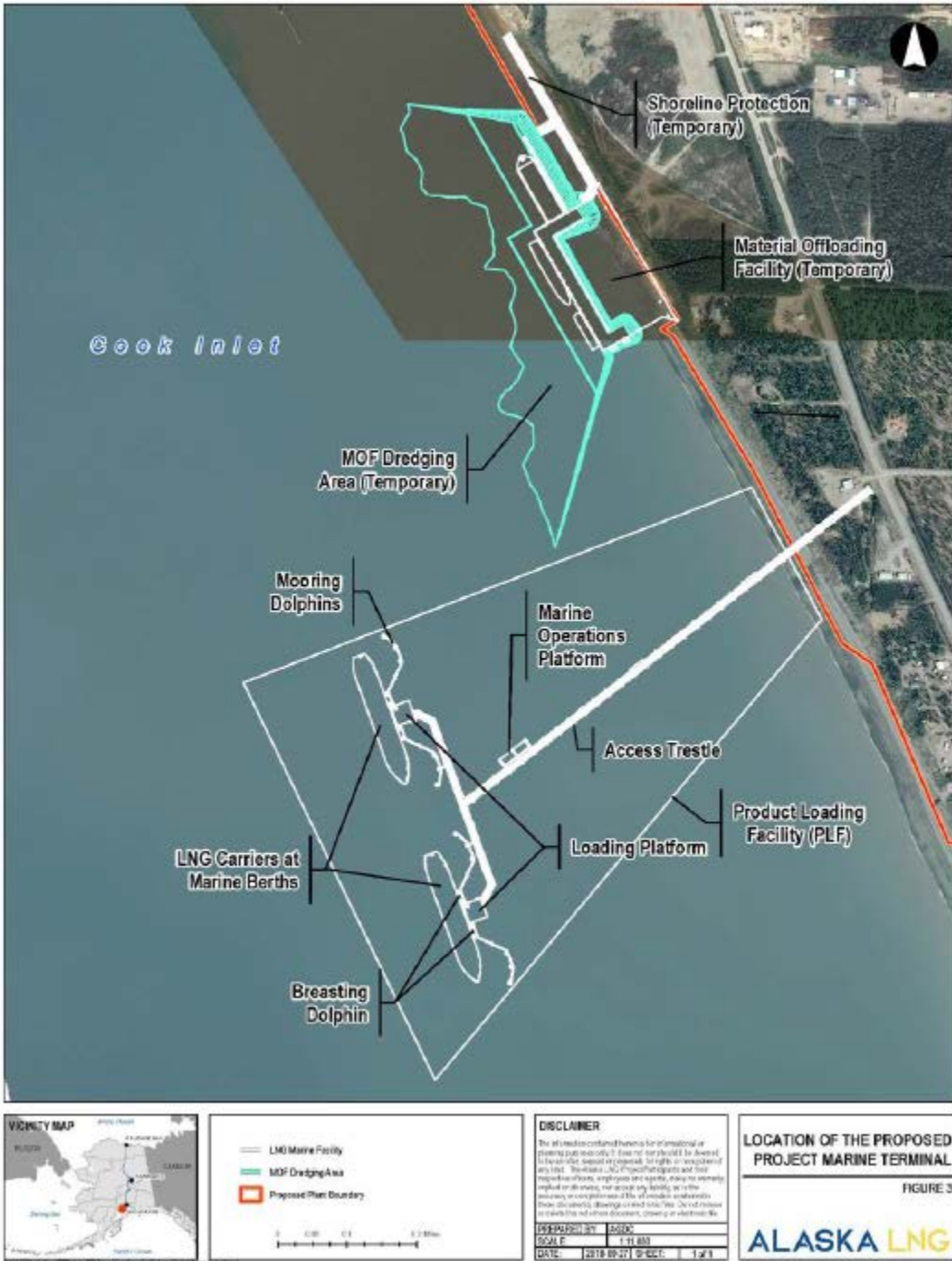


Figure 13. Marine Terminal Offloading Facility, near Nikiski

MOF Dredging

Dredging will be conducted over two ice free seasons. Dredging at the Marine Terminal MOF (Figure 14 and Figure 15) during the first season of marine construction may be conducted with either an excavator or clamshell (both mechanical dredges). Various bucket sizes may be used. Sediment removed will be placed in split hull or scow/hopper barges tended by tugs that will

transport the material to a disposal site (described below).

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

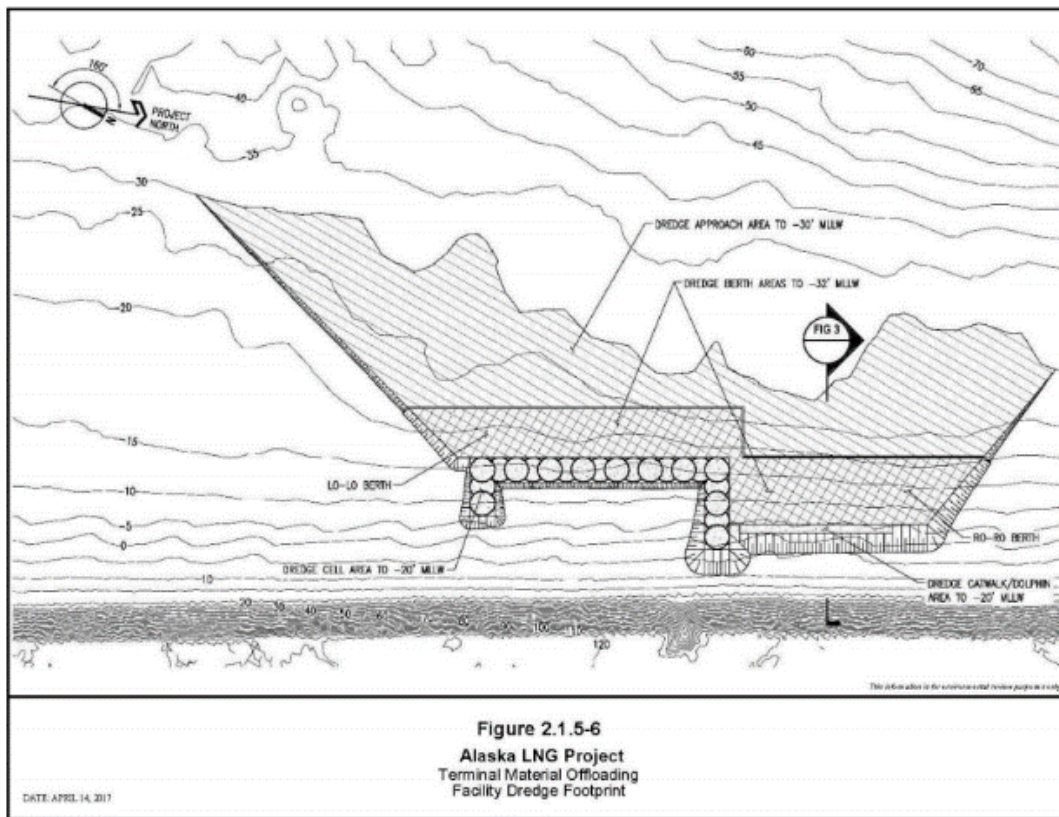


Figure 14. Dredging footprint of the Marine Terminal MOF near Nikiski

AGDC proposes a new offshore-unconfined aquatic dredged material disposal site (Figure 15) to accommodate the total volume of material dredged for the Marine Terminal MOF. AGDC has identified two potential sites and plans to permit both for potential use by the project. One open-water disposal location (DP1) will be about 4 miles west of the MOF. DP1 was selected because it is in relatively deep water (between -60 and -85 ft MLLW) with strong currents (over 6.5 kn peak flood and over 5.5 kn peak ebb), which will disperse dredged sediment placed at the site and prevent mounding of the material. An alternative open water disposal location (DP2) will be in deeper water (between -85 to -110 ft MLLW). Dredged material transport and placement will require a total of 1,200 acres. AGDC conducted sediment dispersion and deposition modeling, which showed that either site could accommodate the anticipated volume of dredged material from the project. The disposal site location will be subject to U.S. Army Corps of Engineers

(COE) approval and concurrence from the U.S. Environmental Protection Agency (EPA).

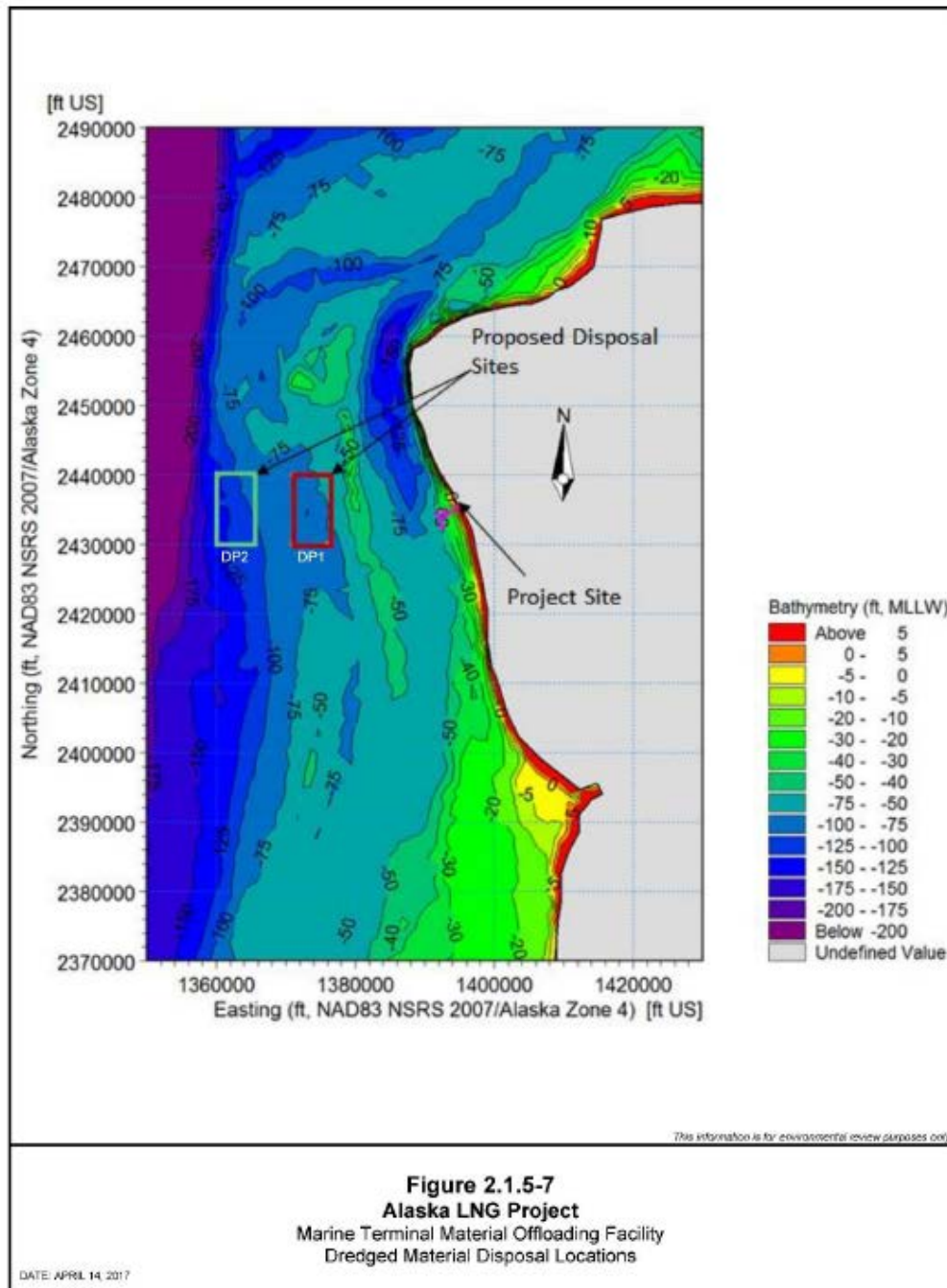


Figure 15. MOF dredging material disposal locations, near Nikiski

Liquefaction Facilities

The Liquefaction Facilities will be constructed on land and will include new facilities constructed on the eastern shore of Cook Inlet in the Nikiski area of the Kenai Peninsula. The Liquefaction Facilities will consist of an LNG Plant, Marine Facilities (described above) and

additional work areas. The LNG Plant components to be constructed on land are:

- three natural gas liquefaction processing units, called trains, capable of liquefying up to 20 million metric tons per year of LNG
- meter station
- two 63.4 million-gallon LNG storage tanks
- two flare systems, including a wet/dry ground flare at the LNG Plant and a low-pressure flare near the Marine Terminal
- power plant systems, including the electric power supply, cathodic protection system, diesel fuel system, fuel gas system, nitrogen system, and waste heat recovery system
- water supply systems, including a freshwater treatment system and a firewater system
- associated infrastructure, including a condensate storage facility, catalysts and chemicals, lighting, communications facilities, and a consolidated building complex



Figure 16. Overview of LNG Plant, near Nikiski

2.1.1.4 Marine Transportation

Increases in marine vessel traffic would occur in Cook Inlet and Prudhoe Bay during construction and in Cook Inlet during operation (Figure 17). The majority of construction

equipment and materials for the project would be shipped to Alaska using ships and oceangoing tugs pulling barges. No single primary port has the current capacity to receive the volume of cargo required for project construction. As mentioned, improved docking facilities in Prudhoe Bay would be used to receive modules, equipment, and material during the ice-free shipping season. In Cook Inlet, primary ports accessible through the Gulf of Alaska (GOA), such as those in Anchorage, Seward, and Nikiski, would be the points of entry for offloading equipment and materials. AGDC will construct a Marine Terminal Material Offloading Facility at Nikiski and a Mainline MOF near the existing Beluga Landing. Each primary port receives specific cargo types, and the modes of transport off the dock and into the interior of Alaska varies. Table 20 summarizes the principal uses of the primary ports during construction.

Table 20. Project-related marine vessel use of primary ports during construction

Primary Port	Role and Use During Project Construction
Port of Alaska	Receipt of food and other construction camp supplies, non-containerized materials, modules that can be transported via truck (up to 410,000 pounds, with an Alaska Department of Transportation and Public Facilities oversized load permit), pipe, and fuel.
Mainline MOF	Receipt of pipe and other materials for the construction of the southernmost spreads of the Mainline Pipeline and for construction of the offshore portion of the Mainline Pipeline.
Port of Dutch Harbor	Used for Gas Treatment Facilities for customs importation of the major sealift modules.
Port of Nikiski (Pioneer MOF and Marine Terminal MOF)	Offloading facility for construction materials and equipment for the Liquefaction Facilities until the Marine Terminal MOF is built.
Prudhoe Bay West Dock Head 4	Used for delivery of materials for the Gas Treatment Facilities and staging for ocean-going tugs.
Port of Whittier	Used for pipe, consumable supplies, and materials that can be carried on rail flatcars.
Port of Seward	Used for pipe, truckable modules, and other construction materials.

AGDC proposes to use the Port of Alaska (POA) and Seward as the primary ports to receive project construction equipment and materials due to their existing rail and road connections, with some materials also arriving at the Port of Whittier. AGDC would use the Port of Dutch Harbor as a staging and customs clearance area for imported project construction materials awaiting transport to the Gas Treatment Facilities by barge. AGDC would construct a new dock head (DH4) at the Prudhoe Bay West Dock Causeway to serve as the unloading facility for the marine sealifts bringing in modules and other project supplies and equipment to the GTP. Table 21 and Table 22 outline the transit route, vessel types, and number of trips during construction.

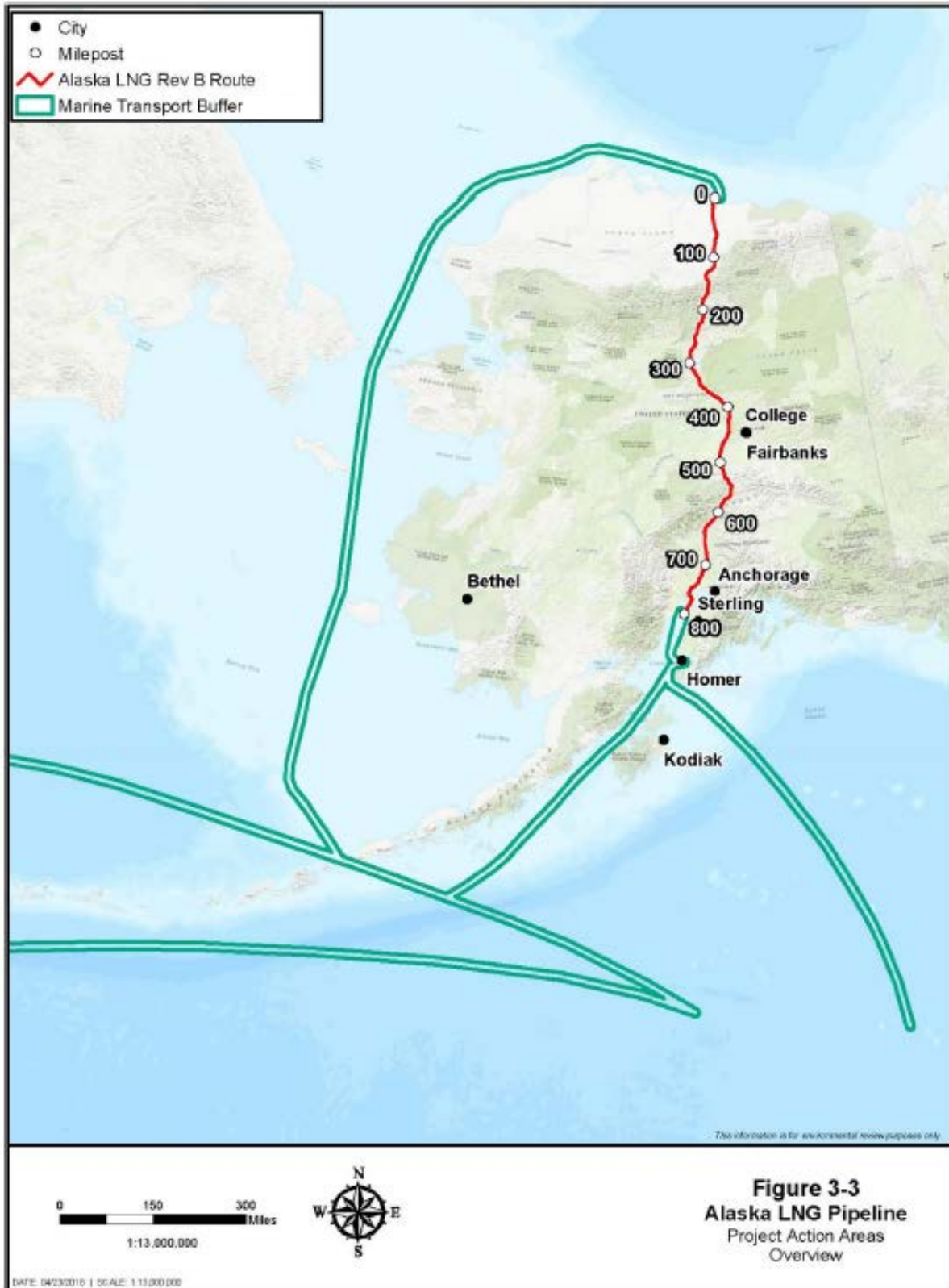


Figure 17. Marine traffic route for Alaska LNG project off Alaska

Table 21. Vessels associated with Prudhoe Bay construction

Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn) ^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction ^b
Prudhoe Bay West Dock / Beaufort Sea/ Chukchi Sea/ Bering Sea / Gulf of Alaska / Lower 48	Year 1-4 ^c	Aug – Oct	Breach bridge barges	12–20	2 (Sunk in position during season then stored ashore over winter)	9-12	61
	Year 1 & 2 ^c	Jul – Oct	Ocean Tug	12–20	9	9	18
Prudhoe Bay West Dock / Beaufort Sea / Chukchi Sea / Bering Sea / North Pacific	Year 1 & 2	Jul – Oct	Ocean Tug	12–20	12	12	24
	Year 3	Jul – Oct			10	10	10
	Year 4	Jul – Oct			9	9	9
On station during open water season and then Beaufort Sea, Chukchi Sea / Bering Sea / Gulf of Alaska for winter	All years (8 total)	Jul – Oct	Assist Dock Tug	11–15	2	2	16
					6	6	48

^a Vessels could travel at faster speeds en route to the project area than when in use for specific project activities. A range has been provided since transiting vessels would also be a risk to marine mammals.

^b Calculated by multiplying the number of round trips per year and total construction years.

^c Vessels would be used pre-construction (effects from pre-construction vessel traffic are analyzed herein).

Table 22. Vessels associated with Cook Inlet construction (ATB=articulated tug barge)

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn)^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction^b
Marine Terminal MOF Construction	Lower 48 via Gulf of Alaska / Cook Inlet	N/A ^c	Apr – Nov	Pre-construction Ocean tug & Barge	12–20	N/A ^c	N/A ^c	N/A ^c
	Local vessels or from Washington State via Gulf of Alaska	Year 1	Apr – Nov	Clamshell crane barge	<10	1	1	1
				Deck Barge & Tug	9–12	1	1	1
				Split-hull dredge barge/scow	8–10	14	3	14
				Tractor tug	11–15	3	3	3
				Work boat	10–26	2	2	2
				Survey Boat	10–26	1	1	1
		Year 2	Apr – Nov	Hydraulic suction cutter-head barge	13	1	1	1
				Deck Barge	9–12	3	3	3
				Split-hull dredge barge/scow	8–10	190	5	190
				Tractor tug	11–15	4	4	4
				Work boat	10–26	2	2	2
				Survey Boat	10–26	1	1	1

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn)^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction^b
Marine Terminal MOF Construction Continued	Cook Inlet or from Washington State via Gulf of Alaska, or local craft	Year 2	Apr – Nov	Derrick Barge (600 tons)	<10	1	1	1
				Derrick Barge (300 tons)	<10	1	1	1
				Derrick Barge (200 to 300 tons)	<10	1	1	1
				Barge for materials/staging	12–20	4	4	4
				Work Boat	10–26	2	2	2
				Survey Boat	10–26	1	1	1
				Ocean Tug	12–20	7	7	7
		Year 3	Apr – Nov	Derrick Barge (600 tons)	<10	1	1	1
				Derrick Barge (300 tons)	<10	1	1	1
				Derrick Barge (200 to 300 tons)	<10	1	1	1
				Derrick Barge (500 tons)	<10	1	1	1
				Barge for materials/staging	12–20	5	5	5
Work Boat	10–26	2	2	2				

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn) ^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction ^b
				Survey Boat	10–26	1	1	1
				Ocean Tug	12–20	8	8	8
		Year 4	Apr – Nov	Derrick Barge (600 tons)	<10	1	1	1
				Derrick Barge (300 tons)	<10	1	1	1
				Derrick Barge (200 to 300 tons)	<10	1	1	1
				Barge for materials/staging	12–20	4	4	4
				Work Boat	10–26	2	2	2
				Survey Boat	10–26	2	2	2
				Ocean Tug	12–20	7	7	7
Marine Terminal MOF Use	Cook Inlet / Gulf of Alaska or North Pacific from Asia	Year 3	May to Sep	Self-propelled RO-RO vessel - module carrier	17–21	7	7	7
			Apr to Oct	Self-propelled LO-LO vessel - module carrier	15–20	10	10	10
		Year 4	Apr to Oct	Self-propelled RO-RO vessel - module carrier	17–21	20	20	20
			Sep to Oct	Self-propelled LO-LO vessel - module carrier	15–20	7	7	7

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn)^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction^b
Marine Terminal MOF Use Continued	Cook Inlet Barge Traffic / Gulf of Alaska	Year 5	Apr to May	Self-propelled RO-RO vessel - module carrier	17–21	5	5	5
		Year 3	Apr – Oct	Ocean-going tug & Barge	12–20	144	144	144
			Apr to Aug	Ocean-going tug & Barge	12–20	5	5	5
			Apr to Oct	Ocean-going tug & Barge	12–20	42	42	42
			May to Oct	Ocean-going tug & Barge	12–20	4	4	4
		Year 4	Apr to Oct	Ocean-going tug & Barge	12–20	144	144	144
			Apr to Aug	Ocean-going tug & Barge	12–20	5	5	5
			Apr to Oct	Ocean-going tug & Barge	12–20	42	42	42
			Sep	Ocean-going tug & Barge	12–20	4	4	4
		All years (4 total)	Apr to Oct	Assist tug (42.5 ton bollard pull)	11–15	2	2	8
			Apr to Oct	Assist tug (15-ton bollard pull)	11–15	4	4	16

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn) ^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction ^b	
Mainline MOF	Cook Inlet / Gulf of Alaska	Year 1 ^f	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	81	81	81	
				Tug & LO-LO flat deck barges (4,300 tons)	15–20	64	64	64	
				Tug & double hull barge (273,000 gallons)	9–12	2	1	2	
		Year 1	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35	
				Tug & double hull barge (273,000 gallons)	9–12	6	1	6	
Mainline MOF Continued		Cook Inlet / Gulf of Alaska	Year 2 ^f	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	73	73	73
					Tug & LO-LO flat deck barges (4,300 tons)	15–20	14	14	14
					Tug & double hull barge (273,000 gallons)	9–12	1	1	1
			Year 2	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn) ^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction ^b
		Year 3	Apr to Oct	Tug & double hull barge (273,000 gallons)	9–21	6	1	6
				Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35
		Year 4	Apr to Oct	Tug & double hull barge (273,000 gallons)	9–21	15	1	15
				Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35
				Tug & double hull barge (273,000 gallons)	9–21	1	1	1
Mainline Pipelay Across Cook Inlet	Gulf of Alaska / North Pacific / Pipe from Seward	Year 3 & Year 4	Apr to Oct	Pipe laying vessel	<10	1	1	1
				Anchor handling tug	12–16	1 ^d	3	3
				Anchor hanging tug (shallow water)	12–16	1 ^d	2	2
				Dynamic Positioned survey vessel	10–26	1	1	1
				Pipe carrier (2,200-ton carrying capacity)	4–14	1 ^d	3	3
POA	Cook Inlet / Gulf of Alaska	Years 1 – 7	Apr to Oct	Container ship added to existing service (potential)	12–25	7	1	49

	Transit Route	Construction Years	Peak Months	Vessel Type	Typical Vessel Speed (kn)^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Duration of Construction^b
Port of Seward	Gulf of Alaska / North Pacific	Year 1	Year-round	Handymax self-propelled pipe carrier (18,000 tons)	11–15	1 ^d	11	11
		Year 2	Year-round	Handymax self-propelled pipe carrier (18,000 tons)	11–15	1 ^d	16	16
	Local	Year 1 – 3	Year-round	Assist tug for pipe vessels	11–15	1d	3	3

Marine Transit Route - Prudhoe Bay Construction

Six sealifts, consisting of two preliminary sealifts (NEG1 and NEG2) transporting materials (smaller modules, equipment, and supplies) and four primary sealifts (Sealifts 1–4) carrying the GTP modules, are proposed for the Alaska LNG project. The timing, numbers of vessels, and numbers of modules associated with each of these six sealifts are identified in Table 23. Dimensions of these types of vessels are provided in Table 24.

The barges will transport the modules from the manufacturing site (likely Asia) with first call being Dutch Harbor to clear customs. The barges will then proceed to a designated Marine Transit Staging Area (MTSA), with Port Clarence being the preferred location for the MTSA at this time. The tug and barge will wait in a secure anchor location until sea ice conditions have improved to 3/10 ice cover or better. The tow spread will be accompanied by a light aircraft which will repeatedly fly along the tow route to give a detailed report on sea and ice conditions. When such conditions are favorable, the tug and barge will proceed to the Prudhoe Bay Offshore Staging Area (PBOSA) located south (shoreward) of Reindeer Island and approximately 5 miles (8 km) north of DH4 to await berthing at DH4.

Table 23. Pre-construction and construction sealifts to West Dock

Sealift	Year	Modules	Barges	Tugs		
				Ocean-going	Primary Assist ^a	Secondary Assist ^a
NEG2 ^b	2022	8	9	9	2	6
NEG1 ^b	2023	57	9	9	2	6
Sealift 1 ^c	2024	17	12	12	2	6
Sealift 2 ^c	2025	15	12	12	2	6
Sealift 3 ^c	2026	10	10	10	2	6
Sealift 4 ^c	2027	9	9	10	2	6

^a Primary and secondary assist tugs remain in Prudhoe Bay area for the season, they are used to transit barges between PBOSA and DH4;

^b Sealifts in NEG years are preconstruction sealifts transporting materials (smaller modules, equipment, and supplies); and

^c Sealifts 1-4 are the primary construction sealifts transporting GTP modules.

The sealift barges will be moved from the PBOSA to DH4 with the shallow draft assist tugs. Offloading operations at DH4 will occur 24 hours a day during periods of favorable oceanography and weather conditions. Current North Slope sealift practices limits operations to wind speed below 20 kn. The barges will be butted up against the dock face and then ballasted down until they rest on the pre-prepared barge bearing pad. Ramps will be placed to connect the barge deck with the dock so that the SPMTs are able to roll under the modules, lift them, then roll out and transport them to the onshore module staging area.

The barges will be demobilized from the PBOSA by ocean-going tugs using standard marine shipping routes. The barges will transit individually through the Beaufort and Chukchi seas

rather than in groups, as occurred during their arrival into Prudhoe Bay. They will be demobilized from Prudhoe Bay on or about mid-September.

Table 24. Dimensions of the types of vessels to be used for sealifts

Vessel Type	Bollard Pull (tons)	Length ft (m)	Width ft (m)	Height ft (m)	Draft ft (m)
Ocean-going tug	120	132 (40.2)	41 (12.5)	--	18 (5.5)
Assist tug (primary)	40	76.1 (23.2)	32 (9.8)	7.1 (2.2)	4 (1.2)
Assist tug (secondary)	15	--	--	--	--
Coastal barge	NA	360 (109.8)	150 (45.7)	20 (6.1)	10 (3.0)
Purpose-built barge	NA	400 (121.9)	135 (41.1)	20 (6.1)	10 (3.0)

Marine Transit Route - Operations

During the life of the project, the Product Loading Facility would facilitate the docking of LNG carriers ranging in size between 125,000 and 216,000 cubic meters (m³). The estimated number of vessels per month ranges between 17 and 30 (204 and 360 per year), with an average of 21 vessels per month, assuming a nominal 176,000- m³ LNG carrier design vessel. Table 25 summarizes the types of vessels and the number of trips per year during operations.

Table 25. Vessels associated with operation of LNG facilities

Transit Route	Vessel Type	Operation Years ^d	Peak Months	Typical Vessel Speed (kn) ^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Life of the Project ^b
Cook Inlet / North Pacific / Asia	LNG carrier	Life of Project	Year-round	14–21	204 to 360 ^c	252 ^c	6,120 to 10,800
Cook Inlet	Tugs	Life of Project	Year-round	11–15	4	4	120
Cook Inlet - Dredging	Hydraulic suction cutter-head barge	Once during operation	Apr - Nov	13	1	1	1

^a Vessels could travel at faster speeds en route to the project area than when in use for specific Project activities. A range has been provided since transiting vessels would also be a risk to marine mammals.

^b Calculated by multiplying the number of round trips per year and total project years.

Transit Route	Vessel Type	Operation Years^d	Peak Months	Typical Vessel Speed (kn)^a	Number of Round Trips Per Year	Number of Vessels	Total Number of Vessel Round Trips For the Life of the Project^b
^c It is assumed that each vessel would only make partial round trips, totaling the equivalent of one round trip between all of the vessels. ^d Project lifetime is 30 years.							

To reduce the risk of aquatic invasive species from vessel traffic, AGDC will implement an Invasives Plan. Heavy lift vessels would ballast loads with cargo rather than water and use minimal amounts of freshwater for ballast. Use of freshwater will reduce the likelihood of transporting marine aquatic invasive species. Aquatic invasive species on or in semi-submersible vessels, barges, and tugs will also be controlled by ballast water regulations. LNG carriers and marine barges used for this project must meet the requirements of the EPA Vessel General Permit and Coast Guard regulations. To ensure compliance with U.S. laws and regulations governing ballast water discharges, AGDC will require visiting vessels to possess documentation to demonstrate compliance with ballast water regulation and best management practices prior to allowing ballast water to be discharged into the berthing area. Adherence to these regulations will reduce the likelihood of project-related vessels introducing aquatic invasive species. AGDC will develop a Ballast Water Management Plan that complies with the above standards. The plan will include protocols and management measures for LNG carriers and ships transporting equipment.

2.1.1.5 Aircraft

Air transport for the AK LNG project is limited to fixed wing aircraft and helicopters that will be used as needed to transport workers, supplies, and equipment to remote areas of Alaska. Light aircraft will also be used to guide barges and tugs through the ice to the Prudhoe Bay Offshore Staging Area during six sealifts as described in Section 2.1.1.4 Marine Transportation.

Airport hubs for the transport of AK LNG project personnel to project sites include the Anchorage International Airport (ANC), Kenai Municipal Airport (ENA), Fairbanks International Airport (FAI), Seattle-Tacoma International Airport (SEA), and the Deadhorse Airport (SCC). There may be some use of tactical airstrips near project sites. No helipads are planned for the liquefaction facility at Nikiski. Most of the planned helipads are at mainline block valves along the terrestrial portion of the pipeline.

Aircraft to be used for construction of the AK LNG project include the Dash 8-100 series airplane (up to 37 passengers), 737-400 sized aircraft (up to 144 passengers), and helicopters. The predicted number of airplane flights per day from each airport are summarized in Table 26.

Table 26. Estimated number of airplane trips to support construction of the AK LNG project

Airport	Aircraft Size (Number of Passengers)	Minimum Flights per Day	Maximum Flights per Day
Deadhorse (SCC)	74 - 144	3	9
Fairbanks (FAI)	74 - 144	5	12
Anchorage (ANC)	74 - 144	4	7
Kenai (ENA)	37	4	4

Helicopter transport is not cost effective and would primarily be limited to pre-construction activities (e.g., surveyors, cultural/environmental resource specialists), transport of senior project personnel during active construction, and for emergency evacuations. AGDC estimates an average of three and maximum of six helicopter round trips per day at each proposed helipad during construction.

2.1.2 Mitigation Measures

- AGDC will implement the following mitigation measures. AGDC will notify NMFS 48 hours prior to the start of each activity in Cook Inlet that may cause harassment of marine mammals. If there is a delay in activity, AGDC will also notify NMFS as soon as practicable.

Time Restriction

- Pile driving will not occur at West Dock during the Nuiqsut whaling season (typically August 25-September 15, but may vary depending on interannual variation in the timing of the bowhead whale migration).
- Pile driving associated with the Mainline Material Offloading Facility (Mainline MOF) will occur only from September 8 – May 31.
- Other than the activities described in the Proposed Activities section (Section 2.1.1)(e.g., sheet pile driving, anchor handling, trenching, pipe-laying and support vessels), AGDC will not engage in in-water sound-producing activities within 10 miles (16 km) of the mean higher high water (MHHW) line of the Susitna Delta (Beluga River to the Little Susitna River) between April 15 and October 15 (activities that produce sound in excess of 120 dB rms re 1 μ Pa @ 1m)².

Protected Species Observer (PSO) Protocols

- PSOs will have the following knowledge, skills and abilities:
 - be in good physical condition and be able to withstand harsh weather conditions for an extended period of time;
 - visual acuity (correction is permissible) sufficient to allow detection and identification of marine mammals (binoculars may be necessary for species identification);

- c. be able to conduct field observations and data collection according to assigned protocols;
 - d. writing skills sufficient to prepare understandable reports of observations and technical skills to complete data entry forms accurately; and
 - e. identifying marine mammals in Alaskan waters to species based upon appearance or behavior;
 - f. ability to classify marine mammal behavior types into pre-established categories.
6. PSOs will have training, orientation or experience with project operations sufficient to accurately report on activities occurring during marine mammal sightings.
7. PSOs will complete project-specific training prior to deployment to the project site (taught by an experienced trainer following a course syllabus approved by NMFS). This course will include training in:
 - a. field identification of marine mammals and marine mammal behavior;
 - b. marine mammal ecology;
 - c. ESA and MMPA regulations;
 - d. mitigation measures outlined in the Biological Opinion;
 - e. PSO roles and responsibilities.
8. PSOs will be positioned such that the applicable shutdown zone for each activity is visible. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360° view of the water (e.g., the elevated bridge on the source vessel, situated on an elevated promontory on land, in aircraft). The PSOs will scan systematically with both the naked eye and while using binoculars.
9. PSOs will have the ability to effectively communicate in real time with project personnel to provide real-time information on marine mammals.
10. PSOs will have the ability and authority to order appropriate mitigation measures, including measures to avoid unauthorized takes of marine mammals.
11. The PSOs will be issued equipment sufficient to carry out their duties. Equipment may include the following:
 - a. Range finder;
 - b. Annotated chart and compass;
 - c. Inclinator;
 - d. Appropriate personal protective equipment;
 - e. Daily tide tables for the project area;
 - f. Watch or chronometer;
 - g. Binoculars (7x50 or higher magnification) with built-in rangefinder or reticles (rangefinder may be provided separately);

- h. Handheld global positioning system;
 - i. A copy of these mitigation measures, the Incidental Take Statement, and the Marine Mammal Monitoring and Mitigation Plan (4MP) printed on waterproof paper and bound or available on a weatherproof electronic device;
 - j. Observation Record forms printed on waterproof paper, or weatherproof electronic device allowing for required PSO data entry.
12. PSO will have no other primary duties beyond watching for, acting on, and reporting events related to marine mammals.
13. PSO will work in shifts lasting no longer than four (4) hours with at least a one (1) hour break from marine mammal monitoring duties between shifts. PSOs will not perform duties as a PSO for more than 12 hours in a 24-hour period.
14. Prior to commencing in-water work or at changes in watch, PSOs should establish contact with person in charge (PIC) and equipment operators. The PSO will brief the PIC as to shutdown procedures if the listed species are observed likely to enter or are within the shutdown zone, and will request that the PIC instruct the crew to notify the PSO when a listed species is observed. If the PIC goes "off shift" and delegates his duties, the designated PIC should contact the PSO on duty to advise of the updated point of contact.
15. The PSOs will perform their duties for 30 minutes before, during, and for 30 minutes after all discrete in-water sound-producing activity, which is defined as an activity with in-water sound production greater than Level B harassment thresholds.

Shutdown Zones and Procedures

16. The **Shutdown Zone** is defined as the area in which all operations are **shut down** in the event a marine mammal enters or appears likely to enter this zone. Shutdown will occur whenever a Cook Inlet beluga whale is observed anywhere within the MMPA Level B monitoring zone. The radii for the Shutdown Zone for each of the project activities are summarized in Table 27 (Prudhoe Bay) and Table 28 (Cook Inlet). Take will be recorded when animal(s) are observed within the calculated Level A or Level B zone (see Section 6 for the definitions of Level A and B harassment and how these zones were calculated). Animals occurring in a Level A zone will be assumed to have been taken by Level A harassment/harm unless it can be demonstrated that the animal did not actually incur level A take according to NMFS acoustic guidance (generally by not remaining in the level A zone sufficiently long enough to incur take).
17. For purposes of monitoring, PSOs are assumed able to monitor for belugas and large cetaceans effectively to a distance of 2 km from a vessel, and 3 km from a land-based station that is at least 30 feet above sea level, using mounted and stable big-eye binoculars. PSOs are assumed able to effectively monitor for Phocids out to 500 m.

Where requirements for immediate actions/responses are noted, the requirements do not apply if they would create an imminent and serious threat to a person, vessel or aircraft. In that event, actions/responses will be taken as soon as possible. If additional mitigation measures are required for specific activities, they are listed in subsections below.

For some activity/species combinations, take may be occurring within a monitoring or

shutdown zone that is too large (greater than 2 km radius) to be effectively monitored by a single PSO or PSO team (e.g., impact pile driving and phocids in Prudhoe Bay; Temporary MOF vibratory pile driving and beluga whales in Cook Inlet). In some situations, this is best addressed by adding additional PSO teams to fully observe the zone. This is typically the case when PSOs can be land based or positioned on stationary observation platforms. However, in other situations, it may be acceptable to sample the monitoring/shutdown zone using a sampling plan that is mutually agreed-upon by NMFS and the action agency or its designated non-federal representative. Such a plan should include proportionate monitoring at all distances within the zone (such as a wedge of a circle), where that wedge at least 10 percent of the total zone (i.e., a 36 degree wedge). NMFS assumes that sampling of the monitoring/shutdown zone will not occur until a mutually-agreed upon plan (by NMFS) is in place.

Table 27. Radii of Level A shutdown zones and Level B monitoring zones for Prudhoe Bay operations

Activity	Level A Shutdown Zone Radius (m)			Level B Monitoring Zone Radius (m)
	Low Frequency Cetaceans	Mid Frequency Cetaceans	Phocids	
Impact of 11.5 or 14-in H-pile	1,200	50	500	650
Impact of 48-in pile	1,600	50	500	2,200
Vibratory of 14-in pile	10	10	10	1,000
Vibratory of sheet piles	20	10	10	4,700
Screeding, and Ice Grading	215			215
Ice Trenching	40			40

^a The calculation of a Level A harassment/shutdown zone for impact pile driving incorporates the total number of daily strikes (i.e. the duration), while calculation of a Level B harassment zone does not. As a result, sometimes the Level A harassment zones end up larger than the Level B harassment zones for the same activity. However, in order for a permanent threshold shift to occur any animal would have to stay in the zone at a particular distance for a duration of time to accumulate sufficient energy for a permanent threshold shift to occur.

Table 28. Radii of Level A shutdown zones and Level B monitoring zones for pile driving and anchor handling associated with the product loading facility (PLF) and temporary and mainline material offloading facilities (MOFs) in Cook Inlet, as well as Cook Inlet-based anchor handling, dynamic positioning, pipe laying, trenching and dredging

Location and Activity	Level A Shutdown Zone Radius (m)				Level B Monitoring Zone Radius (m)
	Low Frequency Cetaceans	Beluga Whales	High Frequency Cetaceans	Phocids	All
Product Loading Facility (PLF) impact pile driving 48-in piles 60-in piles	3,200	3,600	2,400	500	3,600
Temporary material offloading facility (MOF) impact pile driving 24-in piles 48-in piles	3,300	3,600	1,800	500	3,600
Temporary MOF vibratory pile driving Sheet piles All size pipe piles	300	5,600	250	250	5,600
Mainline MOF vibratory pile driving Sheet Piles	300	3,200	250	250	3,200
Mainline MOF impact pile driving Sheet Piles	1,200	800	1,000	500	800
Anchor Handling (Locations 1-4) , Dynamic Positioning, pipelaying, and trenching ^c	N/A	2,900 ^b	N/A	N/A	2,900
Dredging/trenching	150	150	150	150	150

^a The shutdown zone radius for beluga whales is equal to the size of the Level B zone radius because no Level A take of belugas is authorized.

^bThe 2,900m zone will be a clearing zone prior to the start of work, since activities cannot start and stop. Beluga whales occurring within this clearing zone during anchor handling operations will be recorded as having been taken by harassment.

^cWhen trenching requires the use of anchor handling or dynamic positioning, the larger monitoring and shutdown zone (2,900 m) applies.

18. If a marine mammal(s) is likely to enter the shutdown zone, AGDC will shut down activities prior to the animal entering the shutdown zone.
19. Shutdown will be initiated at the PSO's direction when warranted due to the presence of marine mammals.
20. If a marine mammal is entering or is observed within an established shutdown zone (Table 27 and Table 28), pile driving must be halted or delayed. Pile driving may not commence or resume until either the animal has voluntarily left and been visually confirmed beyond the shutdown zone; 15 minutes have passed without subsequent detections of small cetaceans and pinnipeds; or 30 minutes have passed without subsequent detections of large cetaceans. Following a shutdown **of more than a 30-minute period**, for pile driving, dredging, screeding, trenching, dynamic positioning, or pipe laying, the PSOs will scan waters within the shutdown zone (Table 27 and Table 28) and confirm no marine mammals are within the shutdown zone for a period of 30 minutes prior to resumption of the in-water sound-producing activity. If one or more marine mammals are observed within or appear likely to enter the shutdown zone, activity will not begin until marine mammals exit the shutdown zone of their own accord **and** the shutdown zone has remained clear of marine mammals for 30 minutes immediately prior to in-water activity. Any marine mammal observed within a shutdown zone (within the Level A or Level B zone) during in-water sound production will be considered taken and will be reported to NMFS in a monthly annual and final report.
21. Prior to commencing pipe laying, use of Dynamic Positioning thrusters, and anchor handling, the PSOs will scan all waters within the shutdown zone (Table 27 and Table 28) and confirm no marine mammals are observed anywhere within the shutdown zone for a period of 30 minutes prior to commencing operations producing sounds capable of causing marine mammal harassment. For the larger sized zones, aircraft may be used to ensure there are no marine mammals within the zone prior to the commencement of in-water work. If one or more marine mammals are observed within or are likely to enter the shutdown zone, activity will not begin until marine mammals exit the shutdown zone of their own accord. If the marine mammals are not observed leaving the zone, PSOs will wait until the zone has been absent of marine mammals for 30 minutes prior to commencing operations that produce sounds capable of causing harassment of marine mammals.

Pile Driving (Impact and Vibratory)

Please refer to the *Shutdown Zones* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to pipe driving and vibratory sheet pile driving installation and removal are below.

22. Pile installation and removal operations (pile driving) in Cook Inlet will be conducted only during daylight hours.
23. For pile driving operations in Cook Inlet and Prudhoe Bay, initial hammering will not begin unless the entire shutdown zone is observable by PSOs.
24. Pile driving installation and removal operations in Prudhoe Bay will be conducted in daylight hours during the open water season to the extent practicable. When pile driving

outside of daylight hours is unavoidable, PSO's will make use of night vision and infrared sensing equipment as described in the 4MP for the AK LNG project in Prudhoe Bay. While pile driving can continue with the use of night vision and infrared sensing equipment, this equipment will not be used to allow initiation of work at night until it is demonstrated that the equipment can effectively monitor for marine mammals throughout the entire zone.

25. For pile-driving at the Mainline MOF near the Beluga River, and on the east side of Cook Inlet near Nikiski associated with the liquefaction facility, AGDC will deploy bubble curtains around piles. If the SSV indicates that the best-performing bubble curtain configuration provides less than a 2 dB reduction in in-water sound beyond the bubble curtain, use of the bubble curtain may be discontinued.
26. For pile driving in Prudhoe Bay, If AGDC needs to pile driving during the contingency period (late Feb through April), in-water pile driving must commence prior to March 1st.

Soft Start

27. Once the shutdown zone has been cleared of all marine mammals, soft-start procedures will be implemented immediately prior to impact pile driving activities. Soft-start is comprised of an initial set of three strikes from the hammer at about 40 percent energy, followed by a 30-seconds waiting period, then two subsequent three-strike sets with associated 30-seconds waiting periods at the reduced energy.
28. If circumstances result in discontinuation of pile driving for greater than 30 minutes, then the PSO will monitor the shutdown zone for 30 minutes prior to the resumption of pile driving, and will ensure that the zone remains devoid of marine mammals for the 30 minutes immediately prior to the restarting of pile driving. Impact Pile driving will resume following an additional soft start.
29. If visibility degrades to where the PSO determines that he/she cannot effectively monitor the entire shutdown zone during pile driving, the applicant may continue to drive the pile section that was being driven to its target depth when visibility degraded to unobservable conditions, but will not drive additional sections of pile. In Prudhoe Bay, pile driving may continue during low light conditions to allow for the evaluation of night vision and infrared sensing devices.
30. Effort will be made to remove as much material impounded by the sheet piles as practicable prior to sheet pile removal.

Anchor Handling/Dynamic Positioning

Please refer to the *Shutdown Zones and Procedures* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to anchor handling/dynamic positioning are below.

31. If marine mammals are observed within the shutdown zone when thrusters may be necessary, the PSO will inform the vessel captain of the marine mammal's location, and if the marine mammals are within the shutdown zone for that species, thruster use will be postponed unless doing so endangers human life. If anchor handling/dynamic positioning is in progress when marine mammals enter this shutdown zone, the crew will be

instructed to complete activities requiring anchor handling/dynamic positioning that are currently underway, and suspend additional activities until the marine mammal is no longer within the zone or has not been observed within the zone for 15 minutes (for pinnipeds) or 30 minutes (for cetaceans).

Pipelay/Trenching

Please refer to the *Shutdown Zones and Procedures* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to pipelay and trenching activities are below.

32. PSOs will be on-watch daily during daylight hours for the duration of the pipelaying/trenching activities.
33. PSOs will be stationed on the pipelay vessel and/or on an elevated platform on land.
34. Should a marine mammal be observed during pipe-laying in Cook Inlet, the PSO will monitor and carefully record any behavioral reactions until the pipe section is fully secure. No new operational activities will be started until the Level B zone is free of marine mammals.
35. All cables used for obstacle removal, pipe-pulling, anchoring etc. will be under tension (i.e., no slack) when in use and will be removed from the project area following their use.

Dredging and Screeding

Please refer to the *Shutdown Zones and Procedures* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to anchor handling/dynamic positioning are below.

36. AGDC will require that pilots of the dredge and barge and support vessels will have clear views of the monitoring zones around each vessel to facilitate effective observations for all protected species. These pilots will enforce the established shutdown zones for all vessels.

Fill Placement

37. Fill material will consist of rock fill that is free of fine sediments to the extent practical, to reduce suspended materials from entering the water column during tidal cycles. Fill material will also be free of invasive marine and terrestrial vegetation species.

Construction and Heavy Machinery

Please refer to the *Shutdown Zones and Procedures* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to construction and heavy machinery are below.

38. Unless otherwise indicated above, a minimum 10 m shutdown zone will be maintained for in-water construction and heavy machinery not addressed elsewhere in these measures.

Vessel

Please refer to the *Shutdown Zones and Procedures* section above for the required shutdown zone(s), and applicable measures. Additional mitigation measures that apply to project vessels are below.

39. The transit of operational and support vessels through the North Slope region is not authorized prior to July 1. This operating condition is intended to allow marine mammals the opportunity to disperse from the confines of the spring lead system and minimize interactions between project personnel/equipment and subsistence hunters. Exemption waivers to this operating condition may be issued by NMFS and USFWS on a case-by-case basis, based upon a review of seasonal ice conditions and available information on marine mammal distributions in the area of interest, and following outreach by the action agencies to potentially affected Native Alaskan communities.
40. The transit route for the vessels will: minimize transit in known biologically important areas (Ferguson et al 2015a,b; Clarke et al. 2015), and avoid designated critical habitat, to the extent practicable.
41. Vessels traveling between West Dock/Endicott and Foggy Island Bay will not exceed speeds of 10 knots in order to reduce the risk of whale strikes.
42. Vessel operators will maintain a vigilant watch for marine mammals to avoid disturbance and vessel strikes.
43. Consistent with NMFS marine mammal viewing guidelines (<https://alaskafisheries.noaa.gov/pr/mm-viewing-guide>), operators of vessels will, at all times, avoid approaching within 100 yards of marine mammals. Operators will observe direction of travel of marine mammals and attempt to maintain a distance of 100 yards or greater between the animal and the vessel by working to alter vessel course or velocity.
44. The vessel operator will avoid placing the vessel between members of a group of marine mammals in a way that may cause separation of individuals in the group from other individuals in that group. A group is defined as being three or more whales observed within 500-m (1641-ft) of one-another and displaying behaviors of directed or coordinated activity (e.g., migration or group feeding).
45. If the vessel approaches within 1.6 km (1 mi) of one or more whales, the vessel operator will take reasonable precautions to avoid potential interaction with the whales by taking one or more of the following actions, as appropriate:
 - a. Steering to the rear of whale(s) to avoid causing changes in their direction of travel.
 - b. Maintaining vessel speed of 10 knots (19 km/hr) or less when transiting to minimize the likelihood of lethal vessel strikes.
 - c. Reducing vessel speed to less than 5 knots (9 km/hr) within 274 m (300 yards) of the whale(s).
46. Vessels should take reasonable steps to alert other project vessels in the vicinity of whale presence.

47. Vessels will not allow tow lines to remain in the water, and no trash or other debris will be thrown overboard, thereby reducing the potential for marine mammal entanglement.
48. The action agencies will ensure that measures to minimize risk of spilling hazardous substances are implemented.
49. Relative to designated North Pacific right whale critical habitat, project watercraft will:
 - a. avoid transiting through designated North Pacific right whale critical habitat (73 FR 19000); or
 - b. travel at speeds of 5 knots (kn) or less within the boundaries of designated North Pacific right whale critical habitat if no PSO is on watch; or
 - c. travel at 10 knots or less, maintain a full-time watch by a PSO, and maintain a minimal distance of 500 yards (457 m) from right whales at all times (see 50 CFR 224.103(c)). The PSO will record the time and geographic coordinates at which vessels enter and exit North Pacific right whale critical habitat.
50. The vessel operator will not purposely approach within 3 nautical miles (nm; 5.5 km) of major Steller sea lion rookeries or haulouts where vessel safety requirements allow and/or where practicable. Vessels will remain 3 nm (5.5 km) from all Steller sea lion rookery sites listed in paragraph 50 CFR 224.103(d)(1)(iii).
51. Project vessel(s) operating in Cook Inlet will remain a minimum of 2.8 km (1.5 nm) seaward of the mean lower low water (MLLW) line between the Little Susitna River and -150.80 degrees west longitude (see Figure 18 for line depicting the approximate MLLW line) to minimize the impacts of vessel sound and avoid strikes on Cook Inlet beluga whales within this highly essential portion of their critical habitat from April 15 – October 15. The Susitna Delta Exclusion Zone is defined as the union of the areas defined by:
 - a. a 16 km (10-mile) buffer of the Beluga River thalweg seaward of the MLLW line,
 - b. a 16 km (10-mile) buffer of the Little Susitna River thalweg seaward of the MLLW line, and,
 - c. a 16 km (10-mile) seaward buffer of the MLLW line between the Beluga River and Little Susitna River.
 - d. The buffer extends landward along the thalweg to include intertidal waters within rivers and streams up to their mean higher high water line (MHHW). The seaward boundary has been simplified so that it is defined by lines connecting readily discernable landmarks.

For vessels operating in the Susitna Delta Exclusion Zone, the following will be implemented:

- e. All project vessels operating within the designated Susitna Delta area will maintain a speed above ground below 4 knots. PSOs will note the numbers, date, time, coordinates, and proximity to vessels of all belugas observed

during operations, and report these observations to NMFS in monthly PSO reports.

- f.** Vessel crew will be trained to monitor for ESA-listed species prior to and during all vessel movements within the Susitna Delta Exclusion Zone. The vessel crew will report sightings to the PSO team for inclusion in the overall sighting database and reports.
- g.** Vessel operators will not move their vessels when they are unable to adequately observe the 100-m zone around vessels under power (in gear) due to darkness, fog, or other conditions, unless necessary for ensuring human safety.

52. AGDC will develop a Transit Management Plan intended to decrease LNG bulk carrier vessel noise and reduce the rate of vessel strikes on marine mammals. The Transit Management Plan will include the following:

- a.** A ship strike avoidance measures package for distribution to all LNG carrier shippers. This package will include the measures provided by NMFS for avoidance of marine mammals (i.e. vessel mitigation measures outlined in Section 2.1.2).
- b.** Training materials for vessel crew members, including a marine mammal identification guide.
- c.** Signing of a terminal use agreement by all shippers indicating their intent to abide by the terms of the Transit Management Plan.
- d.** Instructions to vessel masters to provide AGDC and NMFS AKR (Table 64) with reports of marine mammal sightings while in the U.S. Exclusive Economic Zone (EEZ) upon docking (including whale species, if known, geographic coordinates, and number). This reporting request will be included in the Ship Strike Avoidance Measures Package provided to each vessel, and compliance with the measures and the reporting must be included in all service agreements with shippers.
- e.** Direction to vessels that, within Cook Inlet (while vessel pilots are aboard), vessels will use minimal speeds (not to exceed 10 knots) that do not sacrifice vessel safety or steerage with the goal of minimizing the vessel's acoustic output while also avoiding disturbance of marine mammals speed is not to exceed 10 knots.

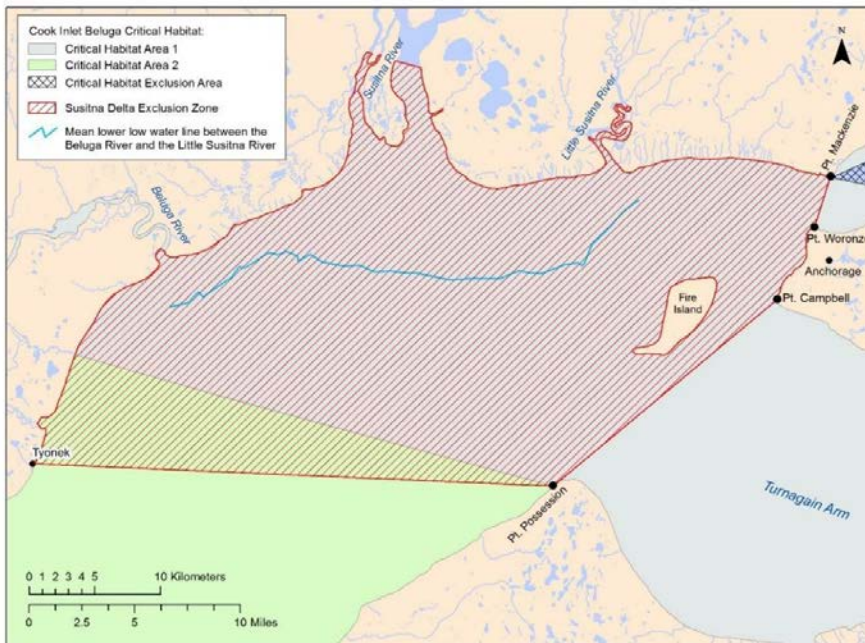


Figure 18. Susitna Delta Exclusion Zone, showing MLLW line between the Beluga and Little Susitna rivers

Aircraft

Please refer to the *Exclusion and Safety Zone* section above for the required shutdown zone, and applicable measures. Additional mitigation measures that apply to aircraft are below.

53. All aircraft will transit at an altitude of 457 m (1,500 ft) or higher, to the extent practicable, while maintaining Federal Aviation Administration flight rules (e.g., avoidance of cloud ceiling, etc.), excluding takeoffs and landing. If flights must occur at altitudes less than 457 m (1,500 ft) due to environmental conditions, aircraft will make course adjustments, as needed, to maintain at least a 457m 1,500 ft separation from all observed marine mammals. Helicopters (if used) will not hover or circle above marine mammals.
54. Aircraft will keep a distance of at least 1.6 km (1 mi) from Steller sea lion rookeries and haulouts.

Other Mitigation Measures

55. All personnel will be responsible for cutting all unused packing straps, plastic rings, and other synthetic loops that have the potential to become entangled around fish or wildlife.

Data Collection

56. PSO will record observations on data forms or into electronic data sheets, electronic copies of which will be submitted to NMFS in a digital spreadsheet format in the monthly, annual, and final reports (Items 60, 61, 62 respectively).
57. PSO will use a NMFS-approved Observation Record. Observation Records will be used to record the following:
 - a. Date and time that activity and observation efforts begin and end;
 - b. Weather parameters (e.g., percent cloud cover, percent glare, visibility) and sea state where the Beaufort Wind Force Scale will be used to determine sea-state (<https://www.weather.gov/mfl/beaufort>);
 - c. Species, numbers, and, if possible, sex and age class (or color) of observed marine mammals, along with the date, time, and location of the observation;
 - d. The predominant sound-producing activities occurring during each marine mammal sighting;
 - e. Description of any marine mammal behavior patterns during observation, including direction of travel and estimated time spent within the Level A and Level B harassment zones while the source was active. Behavioral reactions of marine mammals observed just prior to, and during, sound producing activities;
 - f. Location of marine mammals (geographic coordinates), distance from observer to the marine mammal, and distance from the predominant sound-producing activity or activities to marine mammals;
 - g. Whether the presence of marine mammals necessitated the implementation of mitigation measures to avoid acoustic impact, and the duration of time that operations were affected by the presence of marine mammals.

Reporting Requirements

58. All reports submitted to NMFS Permits Division will also be simultaneously submitted to NMFS AKR.
59. **Exceedance of Authorized Take** - AGDC will immediately notify NMFS AKR (see Table 29 for contact information) if the number of Cook Inlet beluga takes documented reaches 80 percent of the authorized takes in any given calendar year during which take is authorized.
60. **Unauthorized Take** - In the event that personnel involved in the construction activities discover an injured or dead marine mammal, the IHA-holder or LOA-holder will report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and to the AKR stranding hotline (877-925-7773, See Table 29) within 24 hours. If the death or injury was clearly caused by the specified activity, the IHA-holder or LOA-holder must immediately cease the specified activities until NMFS is able to review the circumstances

of the incident and determine what, if any, additional measures are appropriate to ensure compliance with the terms of the IHA or LOA. The IHA-holder or LOA-holder must not resume their activities until notified by NMFS.

The report must include the following information:

- a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
- b. Species identification (if known) or description of the animal(s) involved;
- c. Condition of the animal(s) (including carcass condition if the animal is dead);
- d. Observed behaviors of the animal(s), if alive;
- e. If available, photographs or video footage of the animal(s); and
- f. General circumstances under which the animal was discovered

If available, photographs or video footage of the animal(s); and general circumstances under which the animal was discovered. A report documenting the unauthorized take of marine mammal(s) will be submitted in a digital format that can be queried, and will include:

- g. Information that will be included in the PSO data collection (Item 54)
- h. Date, time, location (latitude/longitude) of incident;
- i. Species identification (if known) or description of the animal(s) involved (estimate on size and length);
- j. Number of animals affected;
- k. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the incident;
- l. Cause of the event (e.g., vessel strike);
- m. Vessel's speed during and leading up to the incident;
- n. Vessel's course/heading and what operations were being conducted (if applicable);
- o. Status of all sound sources in use;
- p. The time the animal(s) was/were first and last observed, if known;
- q. Description of the behavior of the marine mammal immediately preceding and following the incident;
- r. Description of avoidance measures/requirements that were in place at the time of the incident and what additional measures were taken, if any;
- s. If available, description of the presence and behavior of any other marine mammals immediately preceding the incident;

- t. Outcome of the incident (e.g., animal dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and
 - u. To the extent practicable, photographs or video of the animal(s).
61. **Vessel Strike** - Though take of marine mammals by vessel strike is not authorized, if a listed marine mammal is struck by a vessel, it will be reported to NMFS (see Table 29 for contact information) within 24 hrs. See mitigation measure 57 for information that will be submitted, as applicable following a vessel striking a marine mammal.
62. **Marine Mammal Stranding** - If PSOs observe an injured, sick, or dead marine mammal (i.e., stranded marine mammal), they will notify the NMFS Alaska Region Marine Mammal Stranding Network at 1-877-925-7773 (Table 29). The PSOs will submit photos and data that will aid NMFS in determining how to respond to the stranded animal. Data submitted to NMFS in response to stranded marine mammals will include the following information:
- a. Date, time, location (latitude/longitude) of first discovery (and updated location information if known and applicable);
 - b. Species or description and number of stranded marine mammals,
 - c. Description of the stranded marine mammal's condition (including carcass condition if animal is dead):
 - d. Event type (e.g., entanglement, dead, floating);
 - e. Behavior of live-stranded marine mammals;
 - f. If available, photographs or video footage of the animal(s); and
 - g. General circumstances under which the animal(s) were discovered.

Monthly Report

63. Monthly reports will be submitted via email to NMFS AKR for all months with project activities by the 15th of the month following the monthly reporting period. For example, for the monthly reporting period of June 1–30, the monthly report will be submitted by July 15th (see Table 29 for contact information). The monthly report will contain and summarize the following information:
- a. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and a list of all in-water sound-producing activities occurring concurrent with marine mammal observations.
 - b. Species, number, location, distance from the vessel, and behavior of all observed marine mammals, as well as associated project activity (e.g., number of power-downs and shutdowns), observed throughout all monitoring activities.
 - c. Observation data in (a) and (b) above will be provided in digital spreadsheet format that can be queried.

- d. An estimate of the number of animals (by species) exposed to sound at received levels greater than or equal to either the Level A or Level B harassment thresholds, with a discussion of any specific behaviors those individuals exhibited.
- e. A description of the implementation and effectiveness of the: (i) terms and conditions of the Biological Opinion's Incidental Take Statement; and (ii) mitigation measures of the IHA or LOA. For the Biological Opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness for minimizing the adverse effects of the action on ESA-listed marine mammals.

Annual Report

64. Within 90 calendar days of the cessation of in-water work each year, a comprehensive annual report will be submitted to NMFS AKR for review. The report will synthesize all sighting data and effort during each activity for each year. NMFS will provide comments within 30 days after receiving annual reports, and the action agency or its non-federal designee will address the comments and submit revisions within 30 days after receiving NMFS comments. If no comments are received from the NMFS within 30 days, the annual report is considered completed. The report will include the following information:
 - a. Summaries of monitoring effort including total hours, observation rate by species and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals.
 - b. Analyses of the effects of various factors that may have influenced detectability of marine mammals (e.g., sea state, number of observers, fog/glare, and other factors as determined by the PSOs).
 - c. Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover.
 - d. Marine mammal observation data (i.e., PSO data as specified in Item 58) with a digital record of observation data provided in digital spreadsheet format that can be queried.
 - e. Summary of implemented mitigation measures (i.e., shutdowns and delays)
 - f. Number of marine mammals during periods with and without project activities (and other variables that could affect detectability), such as: (i) initial sighting distances versus project activity at the time of sighting; (ii) closest point of approach versus project activity; (iii) observed behaviors and types of movements versus project activity; (iv) numbers of sightings/individuals seen versus project activity; (v) distribution around the source vessels versus project activity; and (vi) numbers of animals detected in the Shutdown Zone.

- g. Analyses of the effects of project activities on listed marine mammals

Final Report

65. In addition to providing NMFS monthly and annual reporting of marine mammal observations and other parameters described above, AGDC will provide NMFS AKR, within 90 days of project completion at the end of the five-year period, a report of all parameters listed in the monthly and annual report requirements above, noting also all operational shutdowns or delays necessitated due to the proximity of marine mammals. NMFS AKR will provide comments within 30 days after receiving this report, and the action agency or its non-federal designee will address the comments and submit revisions within 30 days after receiving NMFS comments. If no comments are received from the NMFS within 30 days, the final report is considered as final.

Summary of Agency Contact Information

Table 29. Summary of agency contact information

Reason for Contact	Contact Information
ESA Consultation Questions, Reports & Data Submittal Contact NMFS Alaska Regional Office	Greg Balogh: greg.balogh@noaa.gov , 907-271-3023
MMPA Questions Contact NMFS Office of Protected Resources	Jolie Harrison (Jolie.Harrison@noaa.gov) Shane Guan: Cook Inlet issues – shane.guan@noaa.gov Leah Davis: Prudhoe Bay issues – leah.davis@noaa.gov
Stranded, Injured, or Dead Marine Mammal (<i>not related to project activities</i>)	Stranding Hotline (24/7 coverage) 877-925-7773
Note: In the event that this contact information becomes obsolete please call NMFS Anchorage Main Office 907-271-5006	

2.2 Action Area

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). For this reason, the action area is typically larger than the project area and extends out to a point where no measurable effects from the proposed action occur.

NMFS defines the action area for this consultation to include the area within which project-related noise levels are ≥ 120 dB re 1 μ Pa (rms), and are expected to approach ambient noise levels (i.e., the point where no measureable effect from the project will occur).

The action area for this biological opinion includes: 1) the area ensonified by project activities around West Dock in Prudhoe Bay (Figure 3); 2) marine transit routes with sound buffer (including from Dutch Harbor to Prudhoe Bay and LNG carriers to and from the LNG facilities at Nikiski, Gulf of Alaska) (Figure 17); and 3) marine and coastal sites where construction of facilities and pipelaying will occur within Cook Inlet (Figure 8).

Within the Prudhoe Bay and Cook Inlet portions of the action area, the loudest underwater sound source with the greatest propagation distance is anticipated to be impact pile driving of 48-in and 60-in steel piles, respectively. Received levels from impact pile driving of these piles with an average source level of 195 dB² may be expected to decline to 120 dB re 1 μ Pa (rms) at a maximum distance of 1,000 km (621 mi) of West Dock.

The 120 dB isopleth was chosen because that is the threshold at which we anticipate pile driving noise levels would approach ambient noise levels (i.e., the point where no measurable effect from the project would occur). While project noise may propagate beyond the 120 dB isopleth, we do not anticipate that marine mammals would respond in a biologically significant manner at these low levels and great distance from the source.

The marine transit route includes the route that vessels will take when transiting from Dutch Harbor to Prudhoe Bay and the route LNG carriers will take to and from the LNG facilities at Nikiski. The marine transit route crosses the Bering Sea, Chukchi Sea, and Beaufort Sea, and Gulf of Alaska (Figure 17). For the marine transit route, the source level of approximately 170 dB at 1 meter are associated with oceanic tug boat noise and are anticipated to decline to 120 dB re 1 μ Pa rms within 1.85 km (1.15 mi) of the source (Richardson et al. 1995).

However, if AGDC, in coordination with NMFS, performs a sound source verification study to determine the actual area that would be ensonified to at least 120 dB re 1 μ Pa_{rms}, the size of the action area (and thus the area within which effects to listed species are expected) may be altered to reflect those site-specific measurements (see Section 2.1.2).

3 APPROACH TO THE ASSESSMENT

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

To jeopardize the continued existence of a listed species means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR § 402.02). As NMFS explained when it promulgated this definition, NMFS considers the likely impacts to a species' survival as well as likely impacts to its recovery. Further, it is possible that in certain, exceptional circumstances, injury to recovery

² Sound source levels from 60" piles were used as a proxy for the 48" piles.

alone may result in a jeopardy biological opinion (51 FR 19926, 19934; June 3, 1986).

Under NMFS's regulations, the destruction or adverse modification of critical habitat means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species (50 CFR § 402.02).

The designations of critical habitat for Cook Inlet beluga whales and North Pacific right whales use the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (81 FR 7414; February 11, 2016) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether the proposed action described in Section 2 of this opinion is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify those aspects (or stressors) of the proposed action that are likely to have effects on listed species or critical habitat. As part of this step, we identify the action area – the spatial and temporal extent of these effects.
- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We determine the rangewide status of critical habitat by examining the condition of its PBFs - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 4 of this opinion.
- Describe the environmental baseline including: past and present impacts of Federal, state, or private actions and other human activities *in the action area*; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 5 of this opinion.
- Analyze the effects of the proposed action. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to stressors and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action's effects on critical habitat PBFs. The effects of the action are described in Section 6 of this opinion with the exposure analysis described in Section 6.2 of this opinion.
- Once we identify which listed species are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our *response analyses*). Response analysis is considered in Section 6.3 of

this opinion.

- Describe any cumulative effects. Cumulative effects, as defined in NMFS's implementing regulations (50 CFR § 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 7 of this opinion.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.
- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 9. These conclusions flow from the logic and rationale presented in the Integration and Synthesis Section 8.
- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action. The reasonable and prudent alternative must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

For all analyses, we use the best available scientific and commercial data. For this consultation, we primarily relied on:

- FERC's DEIS, including Appendix O – Biological Assessment
- Proposed Rule: Cook Inlet LOA
- IHA application: Prudhoe Bay
- Recovery Plans – Cook Inlet beluga whale, blue whale (draft), humpback whale, North Pacific right whale, sei whale, sperm whale, Steller sea lion (Western DPS), Chinook salmon (lower Columbia, upper Columbia spring run, Puget Sound, snake river fall run, snake river spring/summer run, upper Willamette) and steelhead (lower Columbia, middle Columbia, Puget Sound, snake river, upper Willamette)

4 RANGEWIDE STATUS OF THE SPECIES AND CRITICAL HABITAT

This opinion considers the effects of the proposed action on the species and designated critical habitats specified in Table 30.

Table 30. Listing status and critical habitat designation for species considered in this opinion

Species	Status	Listing	Critical Habitat
Bowhead whale (<i>Balaena mysticetus</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
North Pacific right whale (<i>Eubalaena japonica</i>)	Endangered	NMFS 2008, 73 FR 12024	NMFS 2008, 73 FR 19000
Humpback whale, Mexico DPS (<i>Megaptera novaeangliae</i>)	Threatened	NMFS 2016, 81 FR 62260	Not designated
Humpback whale, Western North Pacific DPS (<i>Megaptera novaeangliae</i>)	Endangered	NMFS 2016, 81 FR 62260	Not designated
Blue whale (<i>Balaenoptera musculus</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Fin whale (<i>Balaenoptera physalus</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Sperm whale (<i>Physeter macrocephalus</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Sei whale (<i>Balaenoptera borealis</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Gray whale, Western North Pacific DPS (<i>Eschrichtius robustus</i>)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Cook Inlet beluga whale (<i>Delphinapterus leucas</i>)	Endangered	NMFS 2008, 73 FR 62919	NMFS 2011, 76 FR 20180
Ringed seal, Arctic subspecies (<i>Phoca hispida hispida</i>)	Threatened	NMFS 2012, 77 FR 76706	Not designated
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	Threatened	NMFS 2012, 77 FR 76740	Not designated
Steller sea lion, Western DPS (<i>Eumetopias jubatus</i>)	Endangered	NMFS 1997, 62 FR 24345	NMFS 1993, 58 FR 45269

Species	Status	Listing	Critical Habitat
Chinook salmon (<i>Oncorhynchus tshawytscha</i>)			
Lower Columbia River ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Upper Columbia River Spring ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Puget Sound ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Snake River Fall ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Snake River Spring/Summer ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Upper Willamette River ESU	Threatened	NMFS 2005 70 FR 37160	NMFS 2005 70 FR 52630
Steelhead trout (<i>Oncorhynchus mykiss</i>)			
Lower Columbia River DPS	Threatened	NMFS 2006 71 FR 834	NMFS 2005 70 FR 52630
Middle Columbia River DPS	Threatened	NMFS 2006 71 FR 834	NMFS 2005 70 FR 52630
Snake River Basin DPS	Threatened	NMFS 2006 71 FR 834	NMFS 2005 70 FR 52630
Upper Columbia River DPS	Threatened	NMFS 2006 71 FR 834	NMFS 2005 70 FR 52630
Upper Willamette River DPS	Threatened	NMFS 2006 71 FR 834	NMFS 2005 70 FR 52630
Puget Sound DPS	Threatened	NMFS 2007 72 FR 26722	NMFS 2016 81 FR 9252

4.1 Species and Critical Habitat Not Likely to be Adversely Affected by the Action

4.1.1 Blue whale, North Pacific right whale, Sei whale, Gray whale, Western DPS Steller sea lion

4.1.1.1 Vessel Traffic

The routes proposed for seagoing project barges and tugs transiting between Dutch Harbor and the North Slope (marine transit route), and construction vessels and LNG carriers transiting between the North Pacific, the Gulf of Alaska, and the Marine Terminal in Nikiski overlap with the ranges of the blue whale, North Pacific right whale, sei whale, gray whale, and Western DPS Steller sea lion. Potential effects from project vessel traffic on these ESA listed species includes

auditory and visual disturbance and vessel collision. Project vessels will have a short-term presence in the Bering and Chukchi Seas, the Gulf of Alaska (GOA), Cook Inlet, and the North Pacific (which NMFS considers to include the Aleutian Islands and the Great Circle transit route for this proposed action).

Vessels will be moving through the Bering and Chukchi Seas as they transit between Dutch Harbor and Prudhoe Bay on the North Slope. There will be up to 186 vessel round trips (or 372 transits) to and from Prudhoe Bay over the course of pre-construction and construction (8 years)(Table 21). We do not know what percentage of total ship traffic to Prudhoe Bay will be due to this project. However, between 2008 and 2015, there were 3140 vessel transits through the Bering Strait, with the number of yearly transits more than doubling from 2008 to 2015 (U.S. Committee on the Marine Transportation System 2016). The number of proposed vessel trips along the marine transit route through the Bering Strait over the course of pre-construction and construction will be very small in comparison to the existing level of vessel traffic in this portion of the action area, which has likely increased further since 2015.

During the four-year construction phase for the Marine Terminal in Cook Inlet, a maximum of 953 project vessel round trips (1,906 transits) may occur in the GOA between Washington (or other locations in the lower 48) and the Marine Terminal site in Nikiski. Additionally, a maximum of 96 round trips (192 transits) may occur through the North Pacific between Asia and Cook Inlet (estimated from Table 22). Vessels will primarily be barges and tugs.

Unlike other regions of Alaska, there currently is no available assessment of vessel traffic traversing the GOA so NMFS is unable to determine how construction-specific traffic will contribute to the overall vessel activity in GOA. However, due to the active nature of vessel traffic through Dutch Harbor and the North Pacific Great Circle Route (Nuka Research and Planning Group 2015b), it can be assumed that some portion of that traffic traverses through the GOA either on the way west to Dutch Harbor or headed back east from Asian ports.

In 2012, vessel Automated Identification System (AIS) data recorded 5,501 transits through the North Pacific (Aleutian Islands, including transits in both directions), the majority of which were bulkers or carriers (Nuka Research and Planning Group 2015b). Many additional fishing vessels that are not in the AIS system use these same waters. The maximum number of project vessel transits during the construction phase of the proposed action (192) will contribute only a very small increase in vessel traffic over the 4-year construction period in Cook Inlet.

It is unclear how much project-related vessel traffic will occur in the GOA during the operations phase. However, there will be an estimated 204–360 vessel round trips (~408–720 transits) per year between the Marine Terminal in Nikiski and Asia for the 30 year duration of operations. Based on the AIS data reported by Nuka Research and Planning Group (2015), transits from project vessels would account for an approximately 7.4 to 13.1 percent increase in the number of vessel transits per year. However, non-project-related vessel traffic was expected to have increased through this area since 2012 and may continue to increase for at least the next decade (Nuka Research and Planning Group 2015), suggesting that the contribution of operations vessels to the overall traffic in this region will be small (less than 7.4–13.1 percent).

AGDC will implement mitigation measures (Section 2.1.2) to minimize or avoid auditory and visual disturbance and potential vessel collisions with marine mammals during project activities. These mitigation measures include, but are not limited to, maintaining a vigilant watch aboard vessels for listed whales and pinnipeds and avoiding potential interactions with whales by implementing a 5 knot (9 km/hour) speed restriction when within 300 yards (274 m) of observed whales. Project vessels will also avoid approaching within 3 nm (5.5 km) of known Steller sea lion rookeries and major haulouts. In addition, vessels will take reasonable steps to alert other vessels operating in the vicinity of whale(s), and will report any dead or injured listed whales or pinnipeds. AGDC will either avoid transiting within designated North Pacific right whale critical habitat or, in the event that such transit through critical habitat cannot be avoided, vessel operators will exercise extreme caution and either observe a 5 knot (9.26 km/hour) vessel speed restriction if no PSO is on watch or observe a 10 knot (19 km/hour) vessel speed restriction if a PSO is on full-time watch. Additionally, AGDC will have PSOs actively engaged in watching for marine mammals, and vessel operators will maneuver vessels to keep at least 500 yards (457 m) away from any observed North Pacific right whales, 100 yards (91.4 m) from other marine mammals, and avoid approaching whales in a manner that causes them to change direction or separate from other whales in their group.

Although some marine mammals could receive sound levels in exceedance of the acoustic threshold of 120 dB from the vessels or be disturbed by the visual presence of barges and tugs, disturbances rising to the level of harassment are extremely unlikely to occur. NMFS has interpreted the term “harass” in the Interim Guidance on the ESA Term "Harass" (Wieting 2016) as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” While listed marine mammals will likely be exposed to acoustic stressors from barging activities, the nature of the exposure (primarily vessel noise) will be low-frequency, with much of the acoustic energy emitted by project vessels at frequencies below the best hearing ranges of many large baleen whales and Steller sea lions. In addition, because vessels will be in transit, the duration of the exposure to ship noise will be temporary and brief. NMFS anticipates that at 10 knots, vessels will ensonify a given point in space to levels above 120 dB for less than 9 minutes. The project vessels will emit continuous sound while in transit, which will alert marine mammals before the received sound level exceeds 120 dB. Therefore, a startle response is not expected. Rather, slight deflection and avoidance are expected to be common responses in those instances where there is any response at all. The implementation of mitigation measures, as specified in Section 2.1.2, is expected to further reduce the number of times marine mammals react to transiting vessels.

The factors discussed above, when considered as a whole, make it extremely unlikely that transiting vessels will elicit behavioral responses from or have adverse effects on blue whales, North Pacific right whales, sei whales, gray whales, or Steller sea lions that rise to the level of harassment under the ESA (Wieting 2016). We expect any effects to listed species to have little consequence and not to significantly disrupt normal behavioral patterns.

Vessels transiting the marine environment also have the potential to collide with, or strike, marine mammals (Gende et al. 2019; Jensen and Silber 2003; Laist et al. 2001). From 1978 to 2012, there were at least 108 recorded whale-vessel collisions in Alaska, with the majority occurring in Southeast Alaska (Figure 19)(Neilson et al. 2012). An additional 56 vessel

collisions have been reported to NMFS since 2012 (NMFS unpublished data). According to Neilson et al. (2012), among larger whales, humpback whales were the most frequently documented victims of ship strikes, accounting for 86 percent of all reported collisions. Fin whales accounted for 2.8 percent of reported collisions, gray whales 0.9 percent, and sperm whales 0.9 percent. The probability of strike events depends on the frequency, speed, and route of the marine vessels, and the distribution and density of marine mammals in the area, as well as other factors. Vanderlaan and Taggart (2007) used records of large whale vessel strikes to develop a model of the probability of lethal injury based upon vessel speed. The model projected that the chance of lethal injury to a large whale struck by a vessel travelling at speeds over 15 kn (28 km/hour) is approximately 80 percent, and that this probability drops to about 20 percent for vessels travelling between 8.6 kn (16 km/hour) and 15 kn (28 km/hour).

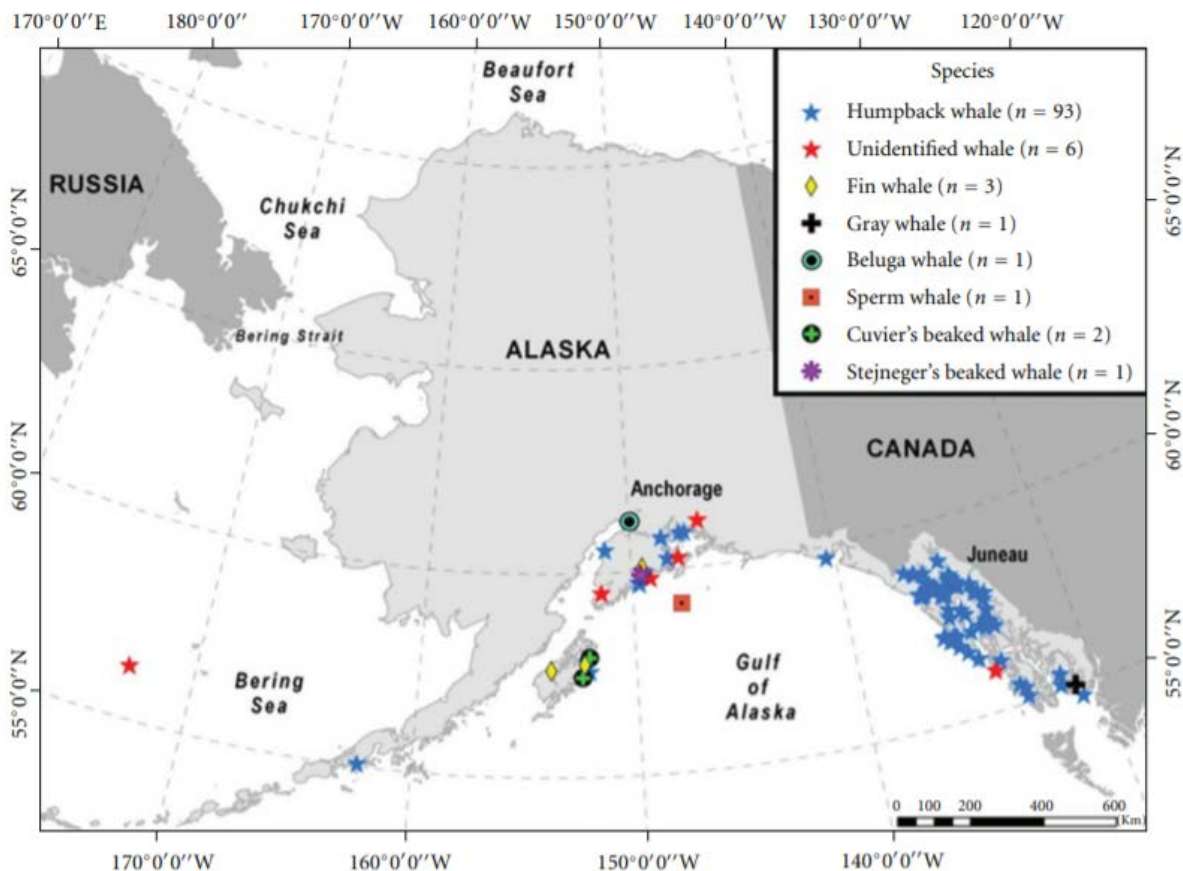


Figure 19. Location of whale-vessel collision reports in Alaska ($n=108$) by species 1978–2011 (from Nielson et al. 2012)

There have been no reported vessel strikes of blue whales, North Pacific right whales, or sei whales in Alaska since 1978. However, there have been a couple reported vessel strikes of gray whales. There are approximately 271 individuals in the gray whale Western North Pacific DPS (listed under the ESA) and 25,849 in the Eastern North Pacific DPS (not listed under the ESA). Studies have recorded 30 gray whales observed in both the Western North Pacific and Eastern North Pacific. Some whales that feed off Sakhalin Island in summer migrate east across the

Pacific to the west coast of North America in winter (45 to 80 percent (Cooke et al. 2019)), while others migrate south to waters off Japan and China (Weller et al. 2016). If the maximum of 80 percent of the Western North Pacific DPS were to migrate to eastern North Pacific waters simultaneously, they would only account for less than 1 percent of possible gray whales that could encounter vessels associated with the action.

There have been 2 known vessel strikes of gray whales in Alaska from 1978 through 2019. Given the very small percentage of Western North Pacific DPS gray whales found in Alaska, it is unlikely that these strikes were from the listed DPS. NMFS concludes that, given that vessel strikes of gray whales are exceedingly rare and the fact that nearly all gray whales in the waters off Alaska are from the Eastern North Pacific DPS, during the life of the project it is extremely unlikely that a vessel associated with the project will strike an ESA-listed Western North Pacific DPS gray whale.

Based on the limited annual number of vessel trips between Dutch Harbor and the North Slope (372 transits over 8 years), the transitory nature of project-related vessel traffic, mitigation measures in place to minimize or avoid effects of transiting vessels on cetaceans and pinnipeds, and decades of vessels transiting in the Bering and Chukchi seas, the GOA, and the North Pacific with only 2 reports of a vessel strike on these species, NMFS concludes that a vessel associated with the project striking a blue whale, North Pacific right whale, sei whale, or gray whale is extremely unlikely to occur.

The risk of vessel strike has not been identified as a significant concern for Steller sea lions. The recovery plan for this species states that Steller sea lions may be more susceptible to ship strike mortality or injury in harbors or in areas where animals are concentrated, e.g., near rookeries or haulouts (NMFS 2008b), which are located throughout the proposed project action area from the GOA up through the Bering Sea. However, only one Steller sea lion has been found with signs that it may have been involved in a vessel collision, located in Kachemak Bay in 2007 (NMFS unpublished data). Further, mitigation measures require project vessels to avoid approaching within 3 nm (5.5 km) of known Steller sea lion rookeries and major haulouts. NMFS concludes that a project vessel striking a Steller sea lion is extremely unlikely to occur.

In summary, NMFS concurs that vessel traffic associated with the proposed action is not likely to adversely affect the blue whale, North Pacific right whale, sei whale, gray whale, or Steller sea lions.

4.1.1.2 Pile Driving and Dredging

The proposed Mainline MOF and Marine Terminal in Cook Inlet overlap with the range of Western DPS Steller sea lions. Blue whales, North Pacific right whales, sei whales, and gray whale have not been observed in this area. Construction at these facilities includes pile driving and dredging, which can result in acoustic and behavioral effects on marine mammals. Noise from pile driving and dredging is unlikely to disturb Steller sea lions as they are rarely observed in this portion of the action area. The nearest haulout, rookery, or other known Steller sea lion use site is at least 200 km from the construction sites (Figure 20). Sightings of Steller sea lions during NMFS aerial survey for belugas in Cook Inlet, indicate that the majority of all Steller sea lions are expected to be found south of the Forelands (Rugh et al. 2005; Shelden et al. 2015a;

Shelden et al. 2013). Since 2012, sixteen Steller sea lions have been reported near oil and gas projects in Cook Inlet (Kendall et al. 2015; Lomac-MacNair et al. 2013; Owl Ridge 2014; Sitkiewicz et al. 2018) and an additional six sighting have occurred during marine mammal monitoring for the Port of Alaska in upper Cook Inlet since 2009 (POA 2019).

Impact and vibratory pile driving are proposed to take place between April and October (months differ by year) between the two project sites. During at least a portion of this time, many Steller sea lions are occupying their rookeries during the pupping and breeding season (late May to early June), making them less likely to be in the middle to upper Inlet. Even if some individuals are present in the action area throughout the pile driving period, the ensonified area is temporary and pinnipeds often frequent industrialized harbors and ports elsewhere in their range. Because of the documented rarity of Steller sea lions in the action area, we conclude that adverse effects on Western DPS Steller sea lions from pile driving are extremely unlikely to occur.

Dredging will occur at the Marine Terminal near Nikiski over the course of two ice free seasons. As with other industrial noises, dredging is not likely to substantially affect Steller sea lion activity if an individual(s) were to be present in the action area. The single Steller sea lion observation at the Port of Alaska in 2019 occurred during dredging activities (POA 2019), suggesting that the noise and activity of dredging machinery in upper Cook Inlet will have a very low probability of impacting Steller sea lions because this region is at the very edge of their distribution. In addition, with the implementation of mitigation measures we do not expect Steller sea lions to encounter levels of project sound capable of causing harassment. Sedimentation due to project activities will not affect Steller sea lion prey due to the extreme tidal conditions and high background sediment load of waters in Cook Inlet.

Because blue whales, North Pacific right whales, sei whales, and gray whales are not expected to occur in the area affected by pile driving and dredging, effects to those species are also extremely unlikely. With the exception of a few gray whale sightings (which were very unlikely to be from the listed DPS), we are unaware of records of these species anywhere in Cook Inlet.

In summary, NMFS concurs that pile driving and dredging associated with the proposed action are not likely to adversely affect the blue whale, North Pacific right whale, sei whale, gray whale, or Steller sea lions.

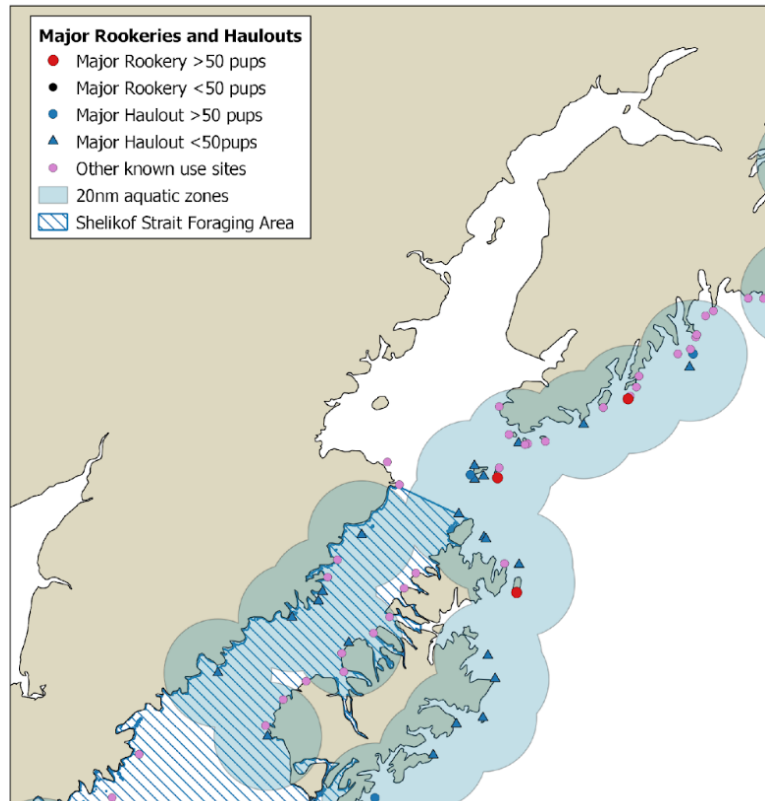


Figure 20. Steller sea lion sites in and near Cook Inlet.

4.1.1.3 Pollution

Pollutant spills or discharges from transiting project vessels, the pipeline across Cook Inlet, and construction sites could affect blue whales, North Pacific right whales, sei whales, gray whales, or Steller sea lions. Pollutants can affect marine mammals if contact with skin, inhalation, or ingestion occurs and the impacts of pollutants depend on duration and severity of exposure. In addition to liquid or gas pollutants, solid waste pollution such as marine debris (ship lines, packing bands, etc.) may enter the marine environment and interact with listed species through entanglement and ingestion. Steller sea lions in particular are vulnerable to entanglement in packing bands, straps, loops, and netting.

AGDC has measures in place to minimize the potential for releases of petroleum products and other pollutants into the marine environment, including, but not limited to a Project Spill Prevention, Control, and Countermeasure Plan and Stormwater Pollution Prevention Plan (see Section 6.4.8 for more details). To address some sources of debris, there is also a mitigation measure specific to cutting of all unused packing straps, plastic rings, and other synthetic loops to prevent entanglement of marine wildlife.

Even in the unlikely event of a spill, spills from transiting vessels would be unlikely to affect listed species as dispersal and evaporation of fuels and other pollutants are expected to occur quickly due to wind and tidal currents. The listed species found throughout the transit routes are also likely to be widely distributed and not in close proximity to the spill source (transiting

vessels). It is unknown what impact marine debris such as packing bands and loops may have on cetacean species. Discarded or lost lines from vessels could become an entanglement hazard for listed cetaceans. However, due to the large area of the project vessel transit routes, the extremely small number of lines expected to be lost from vessels associated with this action, the ability of lines and other debris to disperse (in contrast to set fishing gear or lines), and the relatively low density of cetaceans, we conclude it is unlikely that listed cetacean species will be affected by marine debris.

Raum-Suryan et al. (2009) assessed Steller sea lion entanglement in marine debris and found that of the 386 individuals observed as entangled, packing bands and rubber bands accounted for 54 and 30 percent of the entanglements, respectively. It is possible that marine debris lost from transiting vessels along the marine transit routes may reach Steller sea lion haulouts and rookeries and be an entanglement threat, particularly between Dutch Harbor and the entrance to Cook Inlet (Figure 20). However, if mitigation measures are followed to cut bands and loops, any marine debris that does reach these areas is unlikely to be a major entanglement threat.

As blue, North Pacific right, sei, and gray whales are not expected to occur where construction will be taking place in Prudhoe Bay or Cook Inlet, we conclude it is highly unlikely that these species will be affected by fuels, other liquid pollution, or marine debris from construction activities. Steller sea lions may occur in the Cook Inlet construction area but sightings in this portion of the action area are rare, and as there are no haulouts or rookeries nearby, their presence would likely be transitory and brief. Due to the large distance between haulouts and rookeries, and the mitigation measures in place to prevent pollution and marine debris, we conclude Steller sea lions are unlikely to be affected by pollution or marine debris associated with construction.

Between the measures in place to 1) prevent and address pollutant spills, 2) reduce the entanglement risk of packing bands and loops, and 3) avoid marine mammals, and the wide distribution and low density of the listed cetaceans throughout the transit portions of the action area, and the rarity of Steller sea lions near construction sites, we conclude that project-related pollutants are unlikely to affect blue whales, North Pacific right whales, sei whales, Western North Pacific gray whales, or Western DPS Steller sea lions.

4.1.2 North Pacific right whale Critical Habitat

North Pacific right whale critical habitat (Figure 21) was designated in areas where this species is known or believed to feed in the eastern Bering Sea and Gulf of Alaska (73 FR 19000; April 8, 2008). The PBFs deemed necessary for the conservation of North Pacific right whales include the presence of specific copepods (*Calanus marshallae*, *Neocalanus cristatus*, and *N. plumchris*), and euphausiids (*Thysanoessa Raschii*) that are primary prey items for the species.

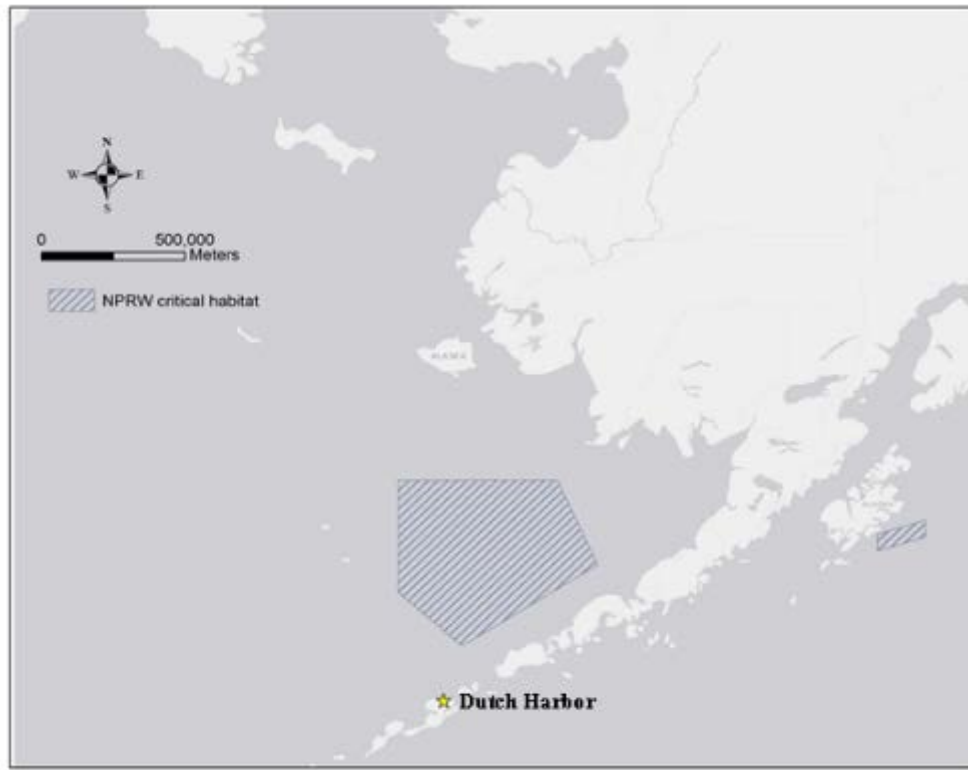


Figure 21. North Pacific right whale critical habitat

The potential effects of the action that may overlap with North Pacific right whale critical habitat include: vessels transiting between Dutch Harbor and Prudhoe Bay and to and from the Marine Terminal in Cook Inlet (Nikiski), exposure to spilled or otherwise-discharged fuel or other chemicals, and acoustic disturbance. While vessels associated with the action may enter designated critical habitat, vessel traffic is not anticipated to affect aggregations of copepods or euphausiids, and therefore will not affect the PBFs associated with North Pacific right whale critical habitat. In addition, given the small number of trips by project vessels per year between Dutch Harbor and Prudhoe Bay, mitigation measures requiring project vessels to avoid North Pacific right whale critical habitat when feasible, the use of the Shelikof Strait for transit into and out of Cook Inlet, and the low likelihood of a spill occurring, we find it extremely unlikely that a fuel spill, other chemical spill, or discharge will occur as a result of this vessel traffic that would have more than a de minimis effect on the PBF for the critical habitat. Even if a small spill were to occur in this critical habitat, it would be expected to evaporate, dissipate, or become entrained within 24 hours, such that any effects to this PBF would be immeasurably small. We also do not expect that noise from transiting project vessels would result in effects on the PBF of the critical habitat that could be meaningfully measured or detected because there is no information indicating that vessel noise has any effects on zooplankton abundance or distribution.

4.1.3 Steller sea lion Critical Habitat

NMFS designated critical habitat for Steller sea lions on August 27, 1993 (58 FR 45269). The following PBFs were identified at the time of listing:

1. Alaska rookeries, haulouts, and associated areas identified at 50 CFR 226.202(a), including:
 1. Terrestrial zones that extend 914 m (3,000 ft) landward
 2. Air zones that extend 914 m (3,000 ft) above the terrestrial zone
 3. Aquatic zones that extend 914 m (3,000 ft) seaward from each major rookery and major haulout east of 144° W. longitude
 4. Aquatic zones that extend 37 km (23 mi) seaward from each major rookery and major haulout west of 144° W. longitude
2. Three special aquatic foraging areas identified at 50 CFR 226.202(c):
 1. Shelikof Strait
 2. Bogoslof
 3. Seguam Pass

Vessels traveling along the marine transit route between Dutch Harbor and Prudhoe Bay, between Dutch Harbor and the Marine Terminal in Cook Inlet, and through the GOA and North Pacific in association with the proposed action would pass through designated critical habitat for western DPS Steller sea lions. Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (Figure 22). Additionally, the route between the Marine Terminal in Cook Inlet and Dutch Harbor for LNG carriers passes through the Shelikof Strait designated foraging area on the north side of Kodiak Island (Figure 22).

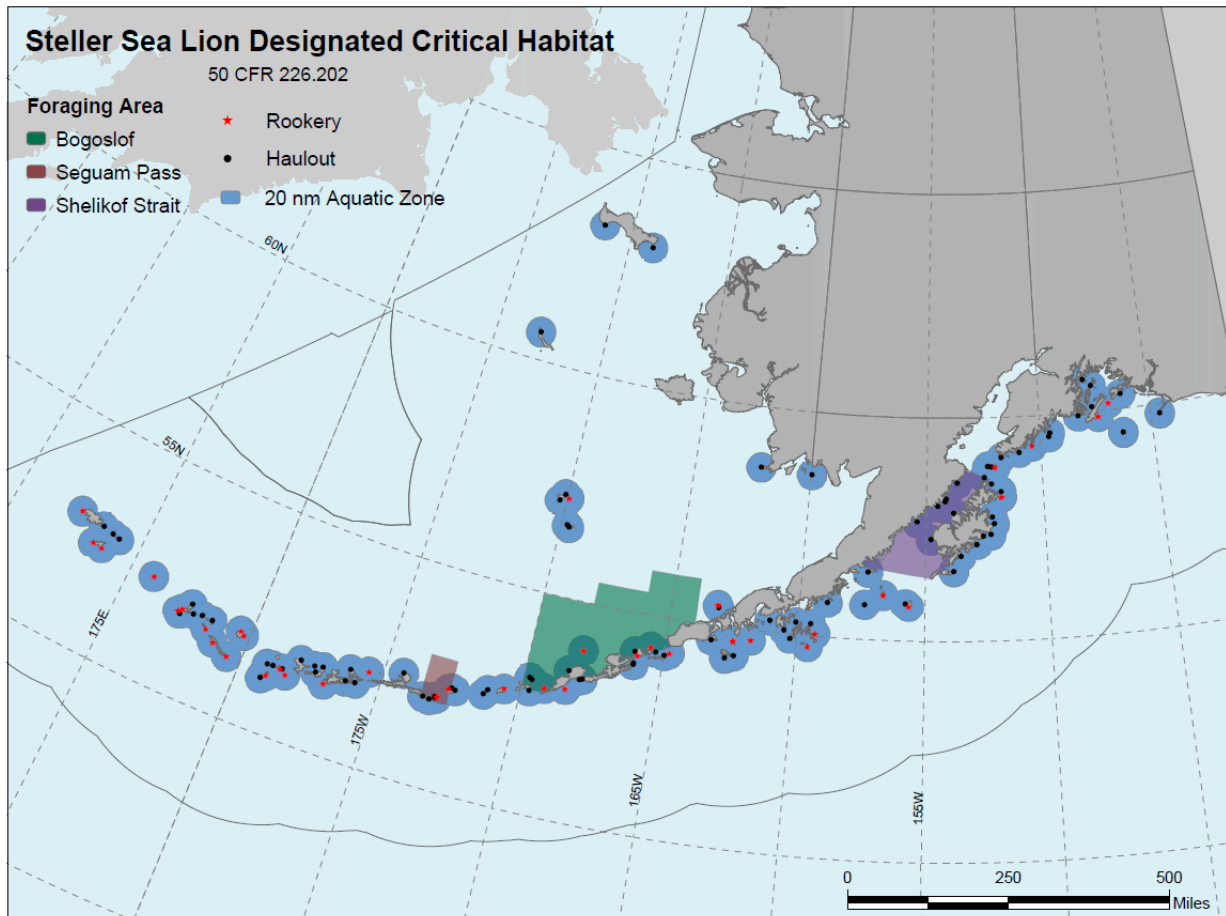


Figure 22. Designated Steller sea lion critical habitat west of 144°W longitude

Designated critical habitat for Steller sea lions includes terrestrial, air, and aquatic habitats that support reproduction, foraging, rest and refuge. These designations were based on the location of terrestrial rookery and haulout sites where breeding, pupping, refuge and resting occurs; aquatic areas surrounding rookeries and haulouts, the spatial extent of foraging trips, and availability of prey items, and rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas. Within the action area, vessels have the potential to transit through the 20nm aquatic zone around rookeries and haulouts, and the Bogoslof and Shelikof Strait foraging areas.

The 3-mile no transit zones are established and enforced around rookeries in the area for further protection. NMFS's guidelines for approaching marine mammals discourage vessels approaching within 100 yards of haulout locations further reduce disturbance by vessels. The Bogoslof foraging area historically supported large aggregations of spawning pollock (Fiscus and Baines 1966; Kajimura and Loughlin 1988). While vessels transiting from Dutch Harbor to Prudhoe Bay or the Marine Terminal may enter the Bogoslof or Skelikof Strait foraging areas, noise associated with vessel operations is not anticipated to affect PBFs or impact foraging. Vessel noise has not been shown to affect fish distribution beyond a startle response, and we presume it would not affect Steller sea lion prey. Steller sea lions are not typically reactive to vessels and are often attracted to them as a potential food source.

Spills or otherwise-discharged fuels may occur in Steller sea lion critical habitat during project-related vessel transit. However, AGDC will be implementing mitigation measures so that project vessels will avoid approaching within 3 nm (5.5 km) of known Steller sea lion rookeries and major haulouts, reducing the likelihood of released fuels from affecting critical habitat before dispersal and evaporation occurs.

Additionally, spills and fuel discharge from the project construction sites in Cook Inlet are possible though unlikely. Regardless, as mentioned above, these construction locations are at least 200 km from critical habitat, and even in the unlikely event of a spill, dispersal and evaporation are expected to occur before discharged materials reach critical habitat. Therefore, we conclude that impacts to critical habitat from spills and discharged fuels are unlikely to occur.

Based on the short term presence of vessels transiting throughout the action area, the distance of construction sites from haulouts and rookeries, and the mitigation measures in place to avoid impacts to marine mammals and designated critical habitat, we anticipate any adverse effects to designated critical habitat for Steller sea lions would be immeasurably small.

4.1.4 Cook Inlet Beluga Whale Critical Habitat

NMFS designated critical habitat for the Cook Inlet beluga whales on April 8, 2011 (Figure 23); 76 FR 20180). Critical habitat includes two areas: critical habitat Area 1 and Area 2 that together encompass 7,800 km² (3,013 mi²) of marine and estuarine habitat in Cook Inlet (76 FR 20180). For national security reasons, critical habitat excludes all property and waters of Joint Base Elmendorf-Richardson (JBER) and waters adjacent to the Port of Alaska. All AK LNG Cook Inlet project components will be constructed within critical habitat Area 2. Though no construction activities will occur within critical habitat Area 1, the AK LNG action area overlaps with both critical habitat areas because the project zones of disturbance extend into Area 1.

Critical Habitat Area 1: Critical habitat Area 1 consists 1,909 km² (738 mi²) of Cook Inlet, north of Threemile Creek and Point Possession (76 FR 20180). Area 1 contains shallow tidal flats or mudflats and mouths of rivers that provide important areas for foraging, calving, molting and escape from predation. High concentrations of beluga whales are often observed in these areas from spring through fall. Additionally, anthropogenic threats have the greatest potential to adversely impact beluga whales in Critical habitat Area 1 (76 FR 20180).

Critical habitat Area 2: Critical habitat Area 2 consists of 5,891 km² (2,275 mi²) south of Critical habitat Area 1 and includes nearshore areas along western Cook Inlet and Kachemak Bay. Critical habitat Area 2 is known fall and winter foraging and transit habitat for beluga whales as well as spring and summer habitat for smaller concentrations of beluga whales (76 FR 20180).

The Cook Inlet Beluga Whale Critical Habitat Final Rule (76 FR 20180) included designation of five PBFs deemed essential to the conservation of the Cook Inlet beluga whale:

1. Intertidal and subtidal waters of Cook Inlet with depths <30 ft (MLLW) and within five miles of high and medium flow anadromous fish streams.

2. Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.
3. Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales.
4. Unrestricted passage within or between the critical habitat areas.
5. Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales.

Although belugas may have abandoned critical habitat off of the Kenai River during summer salmon runs, they make heavy use of salmon runs elsewhere in Upper Cook Inlet, most notably using waters near the mouth of the Susitna and Beluga rivers, and rivers feeding into Knik Arm and Chickaloon Bay (Goetz et al. 2012). Salmon returns in Cook Inlet drainages remain strong, but fewer salmon runs may be available to belugas due to anthropogenic activity. Little information is available on salmon returns to those drainages most heavily exploited by Cook Inlet beluga whales. It is unknown how the newly established personal use dipnet fishery on the Susitna River from July 10-31 each year may affect future salmon returns or whether the human activity associated with this fishery may reduce prey availability to the beluga whales that rely heavily upon Susitna drainage salmon.

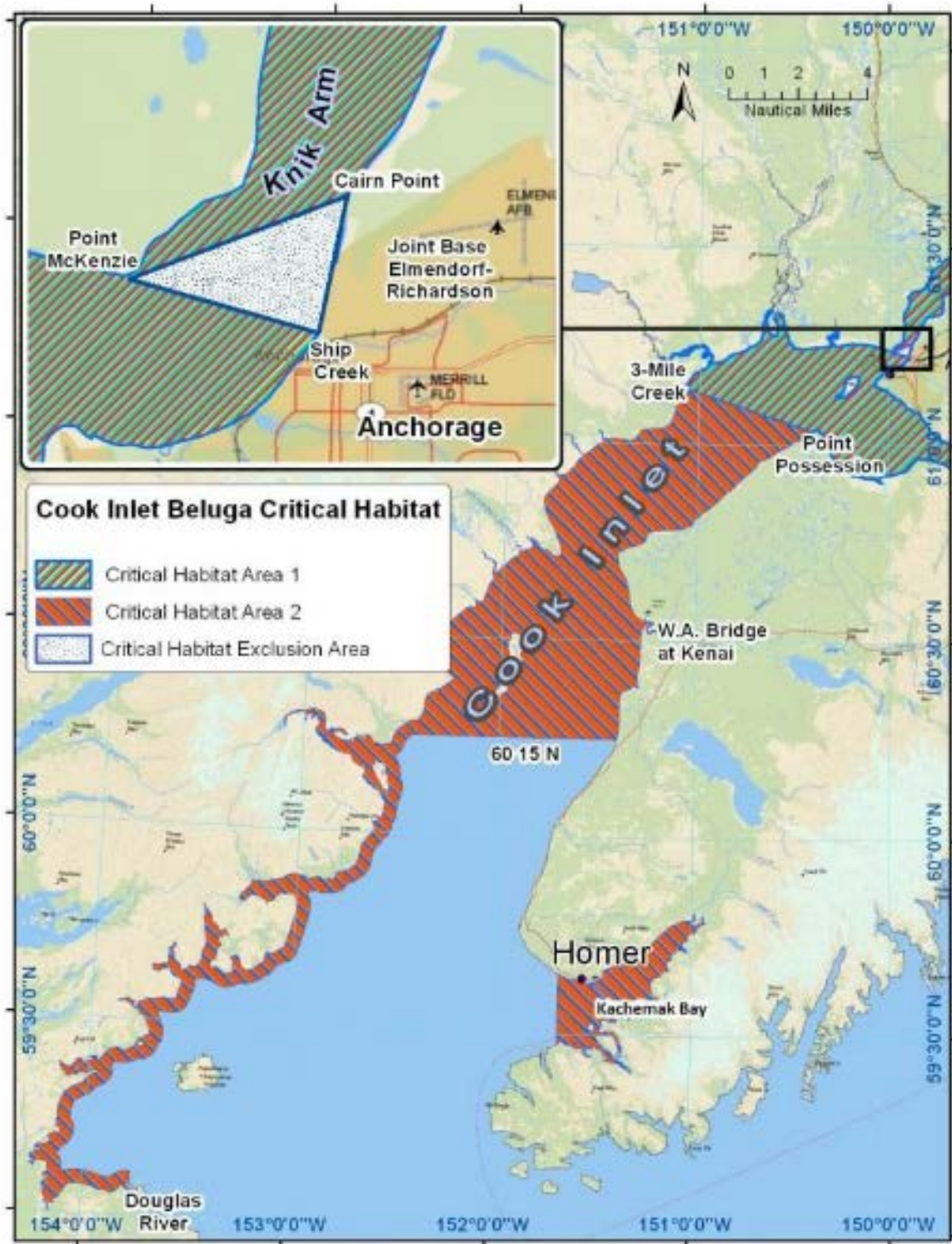


Figure 23. Designated Cook Inlet beluga critical habitat

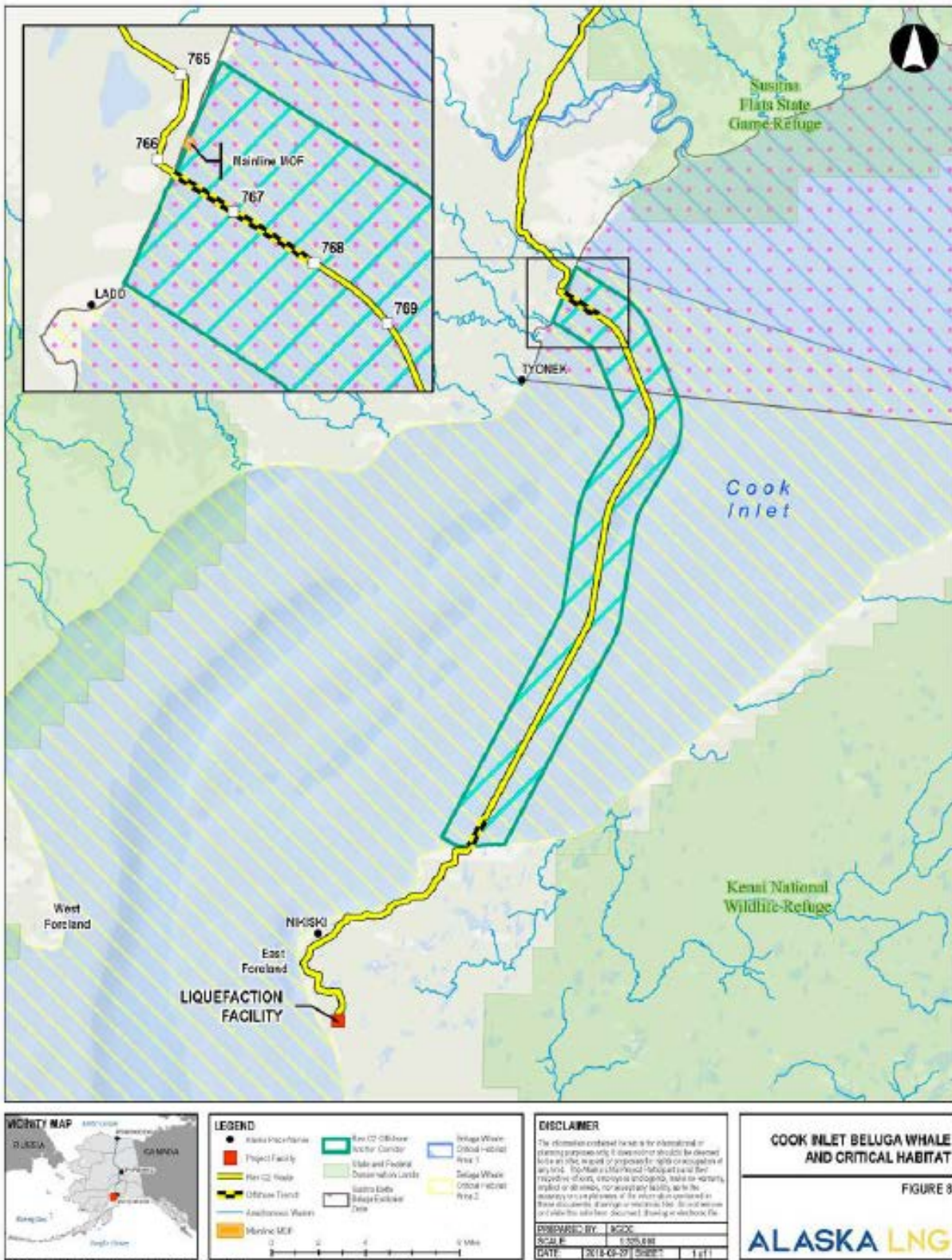


Figure 24. Alaska LNG mainline pipeline Cook Inlet crossing and designated Cook Inlet beluga whale critical habitat.

All of the construction and facilities for the proposed project in Cook Inlet are located within Area 2 critical habitat for the beluga whale (Figure 24). As discussed above, Area 2 is largely based on areas of dispersed fall and winter feeding and transit, where whales typically occur in lower densities or deeper waters. It includes both near and offshore areas of the mid and upper Inlet, and nearshore areas of the lower Inlet. The Mainline MOF and the Mainline entrance into Cook Inlet occur just enough south of the border for critical habitat Area 1 (Figure 24) that noise from pile driving capable of causing take is not expected to extend into that portion of critical habitat. These proposed facilities are approximately 9 km south of the entrance of the Beluga River into Cook Inlet.

The following describes the effects of the proposed AK LNG project on designated Cook Inlet beluga whale critical habitat (50 CFR § 226.220(c)). Section 4.3.5.1 describes the geographical extent and Physical and Biological Features (PBFs) of designated Cook Inlet beluga whale critical habitat. NMFS has determined that the only stressors that may affect Cook Inlet beluga whale critical habitat are the following: noise from pile driving, pipe laying, and anchor handling, turbidity and sea floor disturbance due to pile driving and dredging, and spills of pollutants. Notably, we do not consider natural gas to be among those pollutants due to its extreme volatility and lack of harmful residue. The effects of the proposed action on these PBFs are described below.

PBF1: Intertidal and subtidal waters of Cook Inlet with depths <30 ft (MLLW) and within five miles of high and medium flow anadromous fish streams.

Potential impacts to PBF1 include increased turbidity, elevation in noise levels during pile driving, and small spills. No high or medium flow anadromous fish streams are within 8 km of the project site, although sound from the project will travel to within 8 km of such streams near the Mainline MOF. At the Temporary MOF/Marine Terminal near Nikiski, the Kenai River is approximately 15 km to the north. Given the distance to the Kenai River, we do not expect noise from pile driving to affect portions of PBF 1 near the Temporary MOF/Marine Terminal. The use of bubble curtains and other mitigation measures that will be in place during pile driving (Section 2.1.2), cause us to conclude that noise and other effects due to pile driving will not have a measurable effect upon waters within PBF 1 that are near the Mainline MOF. Impacts from noise on beluga whales and their prey species are discussed in Section 6.4.12 *Effects of Noise on Prey Species* and Section 6.3.1. *Major Noise Sources*.

As discussed in Section 6.4.5 (*Sea Floor Disturbance and Habitat Alteration*), pile installation may temporarily increase turbidity resulting from suspended sediments. Any increases would be temporary, localized, and minimal. AGDC must comply with state water quality standards during these operations by limiting the extent of turbidity to the immediate project area. In general, turbidity associated with pile installation is localized to about a 25-foot (7.6 m) radius around the pile (Everitt et al. 1980) and the plume of sediment created by dredging and spoils disposal is also expected to be limited spatially to about 600 m. The turbidity created by trenching is not expected to be any greater than that produced by dredging and the majority of the trenching will occur across Cook Inlet, far from the mouths of any anadromous streams. Therefore, it is extremely unlikely that increased turbidity from the project would occur in waters within this PBF.

As discussed above in the Section 6.4.9 (*Unauthorized Discharges*), small spills are expected to rapidly disperse due to tide-induced turbulence and mixing. Therefore, small spills are expected to have minimal impact to anadromous fish streams. Notably, we draw a distinction between spills of fluids that may leave behind residues that are harmful to belugas (e.g. oil), and releases of extremely volatile substances such as natural gas, which leave behind no residue that we expect to be harmful to belugas. Releases of natural gas (including from bulk carriers) are not expected to have any effect upon marine mammals due to the extremely volatile nature of LNG and the high likelihood that the liquid will vaporize even before coming into contact with water. LNG that does contact water from above will evaporate without leaving any detectable residue or causing hypoxia in the water column (Council of Canadian Academies 2016). The only potentially harmful effect of a natural gas leak would be effects to prey due to depletion of oxygen from a plume of water downstream from the release site, an effect that most beluga prey (fish) will be able to avoid due to their behavior, or due to extreme tidal mixing which will greatly reduce the size of the hypoxic plume. We consider the effects of natural gas releases upon this PBF to be immeasurably small.

PBF 2: Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.

Potential impacts to PBF2 include increased turbidity, elevation in noise levels during pile driving, and small spills (but not releases of natural gas). As described in PBF1 and in Section 6.4.5 (*Seafloor Disturbance and Habitat Alteration*), pile installation may temporarily increase turbidity resulting from suspended sediments. AGDC must comply with state water quality standards during these operations by limiting the extent of turbidity to the immediate project area. In general, turbidity associated with pile installation is localized to about a 25-foot (7.6 m) radius around the pile (Everitt et al. 1980) and the plume of sediment created by dredging and spoils disposal is also expected to be limited spatially to about 600 m. The turbidity created by trenching is not expected to be any greater than that produced by dredging and the majority of the trenching will occur across the width of Cook Inlet, more than 9 km from the mouths of any anadromous streams, thus there would be no measurable effects to this PBF.

The locations of the facilities are in near shore areas (including intertidal zones) that undergo extremes in temperature, hydration, and salinity due to the extreme tidal fluctuations. Such areas are typically low in productivity or favor productivity of small benthic invertebrates that are not major food items for fish species composing this PBF. Consequently, the ability of these areas to produce invertebrate prey that are valuable to these fish species is naturally very low. We conclude that any increases in turbidity would be temporary, localized, and have no measurable impacts to prey species composing this PBF directly, or indirectly through effects to their prey.

As discussed above in Section 6.4.12 (*Effects of Noise on Prey Species*), fish may respond to noise associated with the proposed action by avoiding the immediate area. However, the impact of noise on beluga prey will be very minor, with barotrauma limited to within a few meters of the pile being driven, and startle responses to noise being temporary, lasting only a short time after the noise ceases. Therefore, adverse effects to PBF2 will be immeasurably small. Also discussed in section 6.4.12, fish may be disturbed by presence of vessels, or struck, but due to the slow speed of the project vessels, we expect that disturbance and vessel strike are very unlikely to occur. Prey may be displaced for short distances during the noise-producing events, but are

expected to resume normal behavior shortly thereafter. The presence of vertical piles in the water will not likely compromise habitat value for marine mammal prey species, and are more likely to enhance it.

In addition to noise effects on PBF2, small unauthorized spills and natural gas leaks have the potential to affect prey species including adult anadromous fishes and out-migrating smolt. Additionally, in fish and shellfish, pelagic eggs and juvenile stages inhabiting near-surface waters may experience lethal and sub-lethal effects from a large spill (Collier et al. 1996; Jewett et al. 2002; Jiang et al. 2017; Marty et al. 1997). Small spills are expected to rapidly disperse due to tide-induced turbulence and mixing. The only potentially harmful effect of a natural gas leak would be effects to prey due to depletion of oxygen from a plume of water downstream from the release site, an effect that most beluga prey (fish) will be able to avoid due to their behavior, or due to extreme tidal mixing which will greatly reduce the size of the hypoxic plume. We expect no project-related measurable change in primary prey in terms of prey population levels, distribution, or availability to belugas. The impact of a small spill or natural gas release (of any size) upon this PBF will be very small, while the probability of a large spill adversely affecting this PBF is very remote. Large quantities of fuel are primarily expected to be in large ships (primarily at the Marine Terminal during operations). Oil tankers will not be part of this action, and safeguards and spill response plans will be in place to guard against the grounding of bulk carriers, or effects thereof.

PBF 3: Waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales.

Chronic exposure to small spills could affect individual whales within their lifetime through accumulation of contaminants, which can affect complex biochemical pathways that suppress immune functions and disrupt the endocrine balance of the body, causing poor growth, development, reproduction, and reduced fitness (Geraci 1990; Geraci and St. Aubin 1990).

As discussed above, authorized discharges of pollutants are regulated through NPDES permits, which undergo separate ESA section 7 consultations (NMFS 2010b). As discussed in PBF 2 and in Sections 6.4.8 and 6.4.9), unauthorized small spills are expected to rapidly disperse due to tide-induced currents, turbulence, and mixing, and the effects are expected to be extremely small. As explained above, we do not consider releases of natural gas to be an event that will degrade waters used by beluga whales.

PBF 4: Unrestricted passage within or between the critical habitat areas.

PBF4 may be affected by noise from pile driving activities and anchor handling. However, the temporary nature of anchor handling in any given location is not expected to restrict passage. Furthermore, anchor handling will occur primarily offshore, where belugas would be able to easily navigate around the noise source. Deposition of sediment will have no effect on this PBF; sediment is constantly being redistributed in this environment, and sediment piles that are anomalous, given local tidal currents, will be quickly removed by those currents.

Cook Inlet beluga whales are unlikely to be physically restricted from passing through critical habitat. However, as discussed above, noise has the potential to cause belugas to avoid the area around the construction sites while pile driving is occurring. This is most likely to occur on the

east side of Cook Inlet as belugas travel north from the Kenai River winter feeding area, past the Nikiski Marine Terminal construction, to reach the summer feeding areas. However, the sounds created by pile driving are expected to extend about 5.6 km and the width of Cook Inlet near Nikiski is approximately 15 km allowing ample room for passage. This fact combined with the facts that: 1) pile driving will not start if belugas are observed in, or appear likely to enter, the Level B harassment zone; and 2) operations will be shutdown whenever a beluga enters or appears likely to enter the Level B zone make it likely that beluga whales will be able to pass by the construction site unimpeded.

On the west side of Cook Inlet the construction site for the Mainline MOF and Mainline is near the margin of Critical Habitat 1 (Figure 24). However, in this location, pile driving will not occur from June 1 to September 7 (important summer feeding time), bubble curtains will be used (if they prove even marginally effective, i.e. a 2 dB reduction in received sound levels), pile driving will not start if belugas are observed in, or appear likely to enter, the Level B harassment zone, and operations will be shut down whenever a beluga enters or appears likely to enter the Level B zone. These mitigation measures coupled with the fact that Cook Inlet is approximately 28 km across at this construction location ensure that belugas will have unimpeded passage within and between critical habitat areas. Based on their reactions during prior similar activities in Cook Inlet, we expect Cook Inlet belugas will pass by the project activities associated with this proposed action, and moreover we expect the mitigation measures to be effective in avoiding restrictions to passage through the action area during pile driving.

Pipelaying and associated anchor-handling activities are not expected to affect this PBF in any measurable amount. While noise associated with these activities may cause temporary behavioral responses in belugas, it will not measurably affect or restrict passage due to its location; belugas will always have plenty of space to comfortably navigate around the vessel, anchors, and noise-producing hardware. The presence of the vessel is not expected to elicit a response from belugas due to the common occurrence of large vessels in the area, and the extremely low velocity exhibited by pipelaying vessels.

PBF5: Waters with in-water noise below levels resulting in abandonment of critical habitat areas by Cook Inlet Belugas.

Pile driving will result in underwater noise in critical habitat. Critical habitat Area 2 has no known areas where belugas concentrate, as they do in Area 1. As mentioned above, Area 2 protects dispersed fall and winter feeding and transit areas in areas where whales typically occur in lower densities or deeper waters. Abandonment of habitat during periods of construction noise has been seen in other marine mammals (Forney et al. 2017; Wartzok et al. 2003). However, Cook Inlet beluga whales have continued to use the narrower passage of Knik Arm through previous periods of pile driving, dredging, and other construction at the Port of Anchorage (POA 2020). Additionally, the implementation of mitigation measures will reduce the impact of in-water noise on Cook Inlet belugas, and the likelihood of temporary abandonment of the area. Beluga whales may avoid portions of the action area during construction, but we expect they would resume using those habitat areas once the most intense noise subsides. As a result, any adverse effects to PBF5 are extremely unlikely to occur.

In summary, activities associated with the proposed AK LNG project are not likely to adversely affect Cook Inlet beluga whale critical habitat. Stressors will have only immeasurably small effects on PBFs 1, 3, and 4. Small spills and small and large natural gas releases are expected to have immeasurably small effects on PBF 2 (prey species), while large spills are extremely unlikely to occur. Project stressors are extremely unlikely to cause abandonment of critical habitat (PBF 5).

4.1.5 Listed Salmonids

Six ESUs of Chinook salmon and six DPSs of steelhead trout listed under the ESA may occur in the action area. As discussed in the listing determinations, there are a number of factors that contributed to declines in many West Coast salmonid stocks and led to NMFS's listing under the ESA of 28 of these stocks, including: overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. Salmon and steelhead from the listed stocks are potentially present in the action area strictly as juveniles or older age classes because their spawning and larval life stages occur only in freshwater streams in the Pacific Northwest.

National Marine Fisheries Service (2016) described the early ocean migration patterns of Pacific Northwest salmonids as follows. In general, spring Chinook salmon move rapidly north varying distances along the continental shelf, as far north as Alaska; fall Chinook remain in local waters (Burke et al. 2013; Fisher et al. 2014; Hayes and Kocik 2014; Myers et al. 1996). Steelhead generally exhibit a unique marine migration pattern and move directly offshore and apparently west across the North Pacific Ocean (Daly et al. 2014; Myers et al. 1996). There can also be large variation within these general groups. There is limited stock-specific information available on the ocean life history and ecology of Pacific Northwest salmonids beyond the end of their first ocean year of life until they return to coastal waters of the Pacific Northwest to spawn (Northwest Fisheries Science Center 2017).

Additional information on the biology and habitat of ESA-listed salmonids can be found in the five-year status reviews, the listing determinations, and recovery plans for these stocks. Although the presence of listed salmonid stocks in Alaskan waters has been documented in a number of studies via recovery of tagged fish and analysis of genetic data (Beacham et al. 2014; Crane et al. 2000; Fisher et al. 2014; Morris et al. 2007; Templin and Seeb 2004; Tucker et al. 2015; Tucker et al. 2012), these studies suggest that they comprise a small percentage of the salmon and steelhead that occur within the action area, particularly in Cook Inlet.

Project noise from vessels, pile driving, and dredging may affect listed salmonid species through masking of other sounds (predators, con-specifics) and behavior changes. As many salmonids use migratory routes that may overlap with shipping between the Pacific Northwest and Alaskan waters, and are thus exposed to vessel noise throughout their range and not just in the project action area, it is unlikely that project-specific vessels and their associated noise will affect the listed salmonid species. Additionally, juvenile and adult salmon are very mobile and can avoid vessels and vessel noise easily, further reducing the likelihood of impacts from project-specific vessel noise and activity.

The only research to date of the effects of pile driving noise on salmon has been with coho salmon (Casper et al. 2012; Halvorsen et al. 2012). These studies defined very high noise level exposures (210 dB re 1 μ Parms) as threshold for onset of injury, and supported the hypothesis that one or two mild injuries resulting from pile driving exposure at these or higher levels are unlikely to affect the survival of the exposed animals in a laboratory environment. Illingworth and Rodkin (2009) studied the effects to juvenile coho salmon from pile driving of sheet piles at the Port of Anchorage in Knik Arm of Cook Inlet. The fish were exposed to in-situ noise from vibratory or impact pile driving at distances ranging from less than 1 meter to over 30 meters. The results of this study showed no mortality of any test fish within 48 hours of exposure to the pile driving activities. Subsequent necropsies showed no effects or injuries as a result of the noise exposure. In all, the best available data indicate that effects from pile driving and construction activities in Cook Inlet would be immeasurably small and highly unlikely to occur.

For the reasons stated above, we conclude that any effects of this action on the listed salmonids included in this consultation—a combination of Chinook salmon evolutionary significant units (ESUs) and steelhead trout DPSs—will be immeasurably small or highly unlikely to occur, and therefore this action is not likely to adversely affect these species. .

4.2 Climate Change

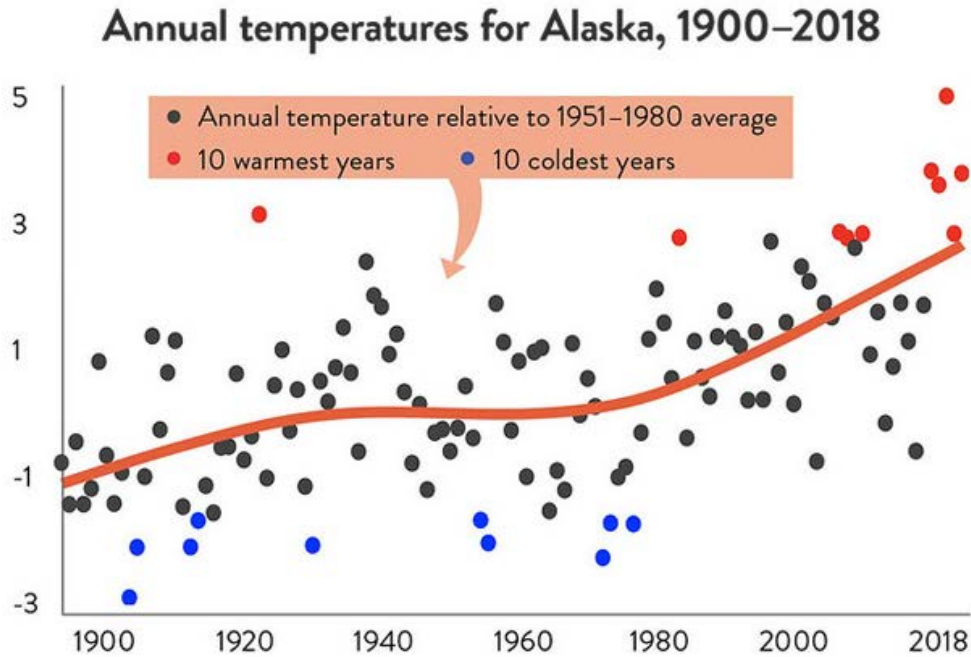
Global climate change is a threat that affects all species, but is expected to affect them differently. Because it is a shared threat, we present this narrative here rather than in each of the species-specific narratives that follow.

There is widespread consensus within the scientific community that atmospheric temperatures are increasing, and will continue to increase, for at least the next several decades (Oreskes 2004; Watson and Albritton 2001). The Intergovernmental Panel on Climate Change (IPCC) estimated that since the mid-1800s, average global land and sea surface temperature has increased by 0.6°C ($\pm 0.2^\circ\text{C}$), with most of the change occurring since 1976 (IPCC 2014). This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). In 2016, the global average atmospheric CO₂ concentration exceeded 400 parts per million, a level Earth's atmosphere has not experienced for at least the past 800,000 years (Lüthi et al. 2008).

Continued emission of greenhouse gases is expected to cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems (IPCC 2014). Data show that 2019 was the second warmest year in the 140-year record and global land and ocean surface temperatures departed +0.95°C (+1.71°F) from average (NOAA National Centers for Environmental Information 2020). The five warmest years in the 1880–2019 record have all occurred since 2015, with nine of the 10 warmest years having occurred since 2005 (NCDC 2020). The upper ocean heat content, which measures the amount of heat stored in the upper 2000 m (6,561 ft) of the ocean, was the highest on record in 2019 by a wide margin (NOAA National Centers for Environmental Information 2020).

The impacts of climate change are especially pronounced at high latitudes. Since 2000, the Arctic (latitudes between 60°N and 90°N) has been warming at more than three times the rate of

lower latitudes because of “Arctic amplification,” a characteristic of the global climate system influenced by changes in sea ice extent, atmospheric and oceanic heat transports, cloud cover, black carbon, and many other factors (NASA 2020; Overland et al. 2017; Serreze and Barry 2011). Across Alaska, average air temperatures have been increasing, and the average annual temperature is now 1.65-2.2°C (3-4°F) warmer than during the early and mid-century (Thoman and Walsh 2019) (Figure 25). Winter temperatures have increased by 3.3°C (6°F) (Chapin et al. 2014) and the snow season is shortening (Thoman and Walsh 2019) (Figure 26).



Credit: Rick Thoman, Alaska Center for Climate Assessment and Policy.

Data source: NASA GISS & UAF/Brian Brettschneider

Figure 25. Alaska's ten coldest years on record (blue dots) all occurred before 1980. Meanwhile, nine of its ten warmest years on record have occurred since 1980.

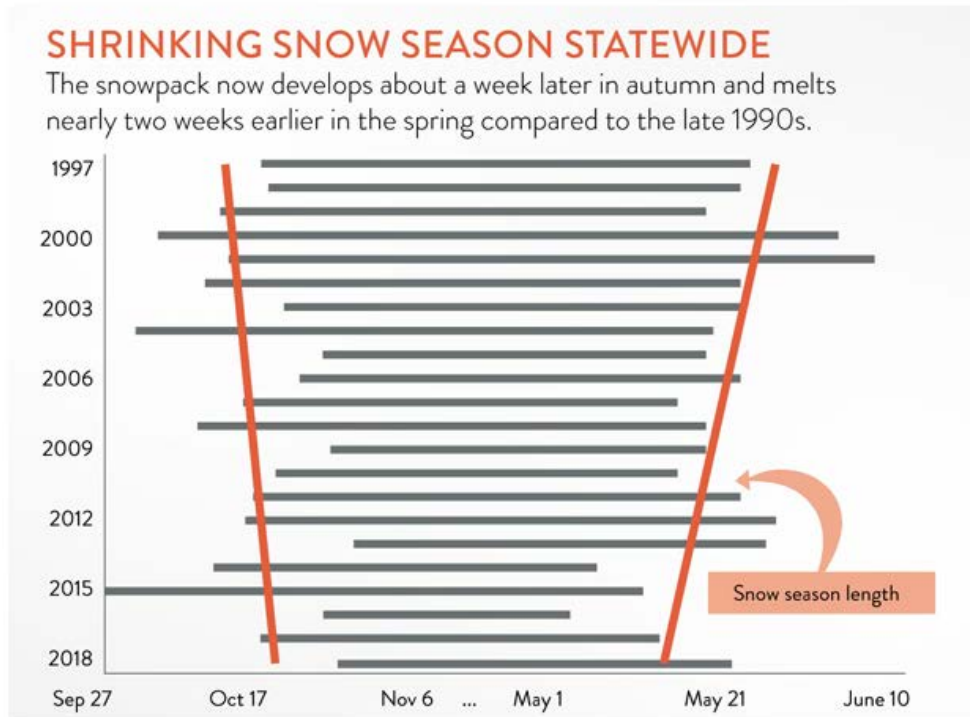


Figure 26. Length of the snow season (gray bars) in Alaska each year from 1997-2018. Orange slanting bars show the trends of the date when the state becomes 50 percent snow covered in fall and when half the winter snow has melted in spring. Image by Rick Thoman, Alaska Center for Climate and Policy.

In the first decade of the 21st century, Arctic sea ice thickness and annual minimum sea ice extent (i.e., September sea ice extent) declined at a considerably accelerated rate. Approximately three-quarters of summer Arctic sea ice volume has been lost since the 1980s (IPCC 2013) and since 1979, the areal proportion of thick ice at least 5 years old has declined by approximately 90 percent (IPCC 2019). The minimum Arctic sea ice extent in 2019 was effectively tied with 2007 and 2016 for second lowest, only behind 2012, which is the record minimum (NSIDC 2019). Wang and Overland (2009) estimated that the Arctic will become essentially ice-free (i.e., sea ice extent will be less than 1 million km²) during the summer between the years 2021 and 2043.

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Burek et al. 2008; Houghton 2001; McCarthy 2001; Parry 2007). Effects of climate change on physical aspects of the marine environment include, among others, increases in atmospheric temperatures; decreases in sea ice; and changes in sea surface temperatures, oceanic pH, patterns of precipitation, and sea level. Such changes have impacted, are impacting, and will continue to impact marine species in a variety of ways (IPCC 2014), such as:

- Shifting abundances
- Changes in distribution

- Changes in timing of migration
- Changes in periodic life cycles of species.

Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2009). Therefore, we expect the extinction risk of at least some ESA-listed species to rise with global warming.

Changes in ocean surface temperature may impact species migrations, range, prey abundance, and overall habitat quality. For ESA-listed species that undertake long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change. For example, cetaceans with restricted distributions linked to water temperature may be particularly exposed to range restriction (Isaac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based on expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, 47 percent will be negatively affected, and 21 percent will be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters, and preferences for shelf habitats (MacLeod 2009).

Changes to prey availability may also negatively impact population sustainability (Simmonds and Elliott 2009). A recent mass of especially warm water in the North Pacific Ocean, referred to as “the blob,” is likely responsible for poor growth and survival of Pacific cod, an important prey species for threatened or endangered humpback whales (Mexico and Western North Pacific DPSs) and Steller sea lions (Western DPS) across southcentral and western Alaska. The 2018 Pacific cod stock assessment (available at https://apps-afsc.fisheries.noaa.gov/REFM/stocks/Historic_Assess.htm, accessed May 31, 2020) estimated that the female spawning biomass of Pacific cod is at its lowest point in the 41-year time series considered in the assessment, following three years of poor recruitment and increased natural mortality during the 2014-2016 Gulf of Alaska marine heat wave. Marine mammals in the Gulf of Alaska were likely impacted by the low prey availability associated with warm ocean temperatures that occurred in the Gulf during 2014-2016 (Bond et al. 2015; Peterson et al. 2016; Sweeney et al. 2018).

Warming waters also resulted in a marked increase in the biomass of Pacific cod and walleye pollock over the Bering Sea shelf, indicating a northward shift of these species between 2010 and 2018 (Thorson et al. 2019). Such changes in the makeup of the local ecosystem may account for events such as seabird die-offs, as these fish species compete with seabirds for prey species. Effects of decreased prey could also impact local marine mammal species that rely on this area for seasonal foraging.

Other climatic changes such as the observed declines in sea ice and the projected substantial declines in depth and duration of snow cover in the Arctic could affect ice and snow-dependent species. Bowhead whales are dependent on sea-ice organisms for feeding and polynyas for breathing. Thus, the early melting of sea ice may lead to an increasing mismatch in the timing of these sea-ice organisms and secondary production (Loeng et al. 2005). However, George et al. (2006) showed that bowhead whales harvested had better body condition during years of light ice cover. Sheldon et al. (2003) noted that there is a high probability that bowhead abundance will increase under a warming global climate. It remains uncertain how climate-driven northward

expansion in the ranges of other baleen whales may affect bowheads.

The Arctic ringed seal could experience a 70 percent reduction in the area of sea ice with suitable snow depths for lairs by the end of this century (Hezel et al. 2012). The persistence of this species will likely be challenged as decreases in ice and, especially, snow cover on sea ice, lead to increased juvenile mortality due to premature weaning, hypothermia, and predation (Cameron et al. 2010; Kelly et al. 2010a). It is likely that, within the foreseeable future, the number of ringed seals will decline substantially, and they will no longer persist in extensive portions of their range (Cameron et al. 2010, Kelly et al. 2010a). The Beringia DPS bearded seals will also likely be challenged as the reduction in the timing and extent of sea ice lead to spatial separation of sea ice from shallow feeding areas and decreases in ice suitable for molting and pup maturation, which will likely compromise their reproductive and survival rates (Cameron et al. 2010).

In addition to changes in temperature, ice, and snow, the world's oceans have also absorbed approximately one-third of the anthropogenic CO₂ released into the atmosphere. While this has buffered the increase in atmospheric CO₂ concentrations (Sabine et al. 2004), as the oceans absorb more CO₂ ocean acidification is occurring, which reduces the amount of calcium carbonate minerals in solution that many organisms use to form and maintain shells (Reisdorph and Mathis 2014). Shelled zooplankton such as pteropods, which are often considered indicator species for ecosystem health, are prey for many species of carnivorous zooplankton, fishes including salmon, mackerel, herring, and cod, and baleen whales (Orr et al. 2005). Under increasingly acidic conditions, pteropods may not be able to grow and maintain shells. It is uncertain if these species, which play a large role in supporting many levels of the Alaskan marine food web, may be able to adapt to changing ocean conditions (Fabry et al. 2008). When the buffering capacity of the oceans to absorb CO₂ is exceeded, the oceans are expected to increase in acidity even more rapidly than we are currently observing.

Interactions between changing climate variables may also impact listed species, and are difficult to predict. As temperatures in the Arctic and subarctic waters are warming and sea ice is diminishing, there is an increased potential for harmful algal blooms (HABs) to affect marine life (Figure 27). HAB-related biotoxins like domoic acid and saxitoxin may pose a risk to marine mammals in Alaska. In the Lefebvre et al. (2016) study of marine mammal tissues across Alaska, 905 individuals from 13 species were sampled including humpback whales, bowhead whales, beluga whales, ringed seals, and bearded seals (see Figure 27 for full list of species tested). Domoic acid was detected in all 13 species examined and had a 38 percent prevalence in humpback whales. Additionally, fetuses from a beluga whale, a harbor porpoise, and a Steller sea lion contained detectable concentrations of domoic acid documenting maternal toxin transfer in these species. Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50 percent) (Lefebvre et al. 2016).



Figure 27. Algal toxins detected in 13 species of marine mammals from Southeast

4.3 Status of Listed Species Likely to be Adversely Affected by the Action

This opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR § 402.02. The opinion also examines the condition of critical habitat throughout the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

For each species, we present a summary of information on the population structure and distribution of the species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether an action's effects are likely to increase the species' probability of becoming extinct.

More detailed background information the status of these species can be found in a number of published documents including stock assessment reports on Alaska marine mammals by Muto et al. (2019), and recovery plans for fin whales (NMFS 2010d), humpback whales (NMFS 1991),

North Pacific right whales (NMFS 2013c), Steller sea lions (NMFS 2008b), and Cook Inlet beluga whales (NMFS 2016b). Cameron et al. (2010) and Kelly et al. (2010b) provided status reviews of bearded and ringed seals. Richardson et al. (1995), Tyack (2000), and Tyack (2009) provided detailed analyses of the functional aspects of cetacean communication and their responses to anthropogenic noise.

4.3.1 Bowhead whales

Status and Population Structure

The International Whaling Commission (IWC) recognizes four stocks of bowhead whale for management purposes. The Western Arctic stock (also known as the Bering-Chukchi-Beaufort stock) is the largest and only stock found in U.S. waters and the action area (Muto et al. 2019).

The bowhead whale was listed as endangered under the Endangered Species Conservation Act (ESCA) of 1969 on December 2, 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and bowhead whales continued to be listed as endangered. Critical habitat has not been designated for bowhead whales. The bowhead whale became endangered because of past commercial whaling. The IWC prohibited commercial whaling, and called for a ban on subsistence whaling in 1977. The United States requested a modification of the ban, and the IWC responded with a limited quota.

Woodby and Botkin (1993) summarized previous efforts to determine a minimum worldwide population estimate prior to commercial whaling and reported a minimum pre-exploration estimate for all stocks of 50,000 whales, with 10,400 to 23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). Subsequently, Brandon and Wade (2006) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190 to 13,950; 5th and 95th percentiles, respectively) bowheads in 1848 at the start of commercial whaling.

Givens et al. (2013) estimated that, from 1978 to 2011, the Western Arctic stock of bowhead whales increased at a rate of 3.7 percent (95 percent confidence interval of 2.8 to 4.7 percent) during which time abundance tripled from approximately 5,000 to approximately 16,000 whales. Similarly, using sight-resight analysis of aerial photographs, Schweder et al. (2010) estimated the yearly growth rate of this stock between 1984 and 2003 to be 3.2 percent. Based on corrected counts of bowhead whales by ice-based observers in 2001, the abundance of the Western Arctic stock was estimated to be 10,545 individuals (coefficient of variation, 0.128) (updated from George et al. (2004) by Zeh and Punt (2005)). Ten years later in 2011, the ice-based abundance estimate was 16,820 individuals (95 percent confidence interval, 15,704 to 18,928) (Givens et al. 2013). Using the 2011 population estimate of 16,820 and its associated coefficient of variation of 0.052, the most recent minimum population estimate for the Western Arctic stock of bowhead whales is 16,100 (Muto et al. 2019).

Distribution

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham

1984; Moore and Reeves 1993). During winter and spring, bowhead whales are closely associated with pack ice or in polynyas (large, semi-stable open areas of water within the ice), and move north as the sea ice breaks up and recedes during the spring. During summer, most of the population is in relatively ice-free waters in the southeastern Beaufort Sea; however, some whales move back and forth between the Alaskan and Canadian Beaufort Sea during the summer feeding season (Quakenbush et al. 2010).

The majority of the Western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi Sea in the spring (April through May), to the eastern Beaufort Sea where they spend much of the summer feeding (June through early to mid-October) before returning again to the Bering Sea in the fall (September through December) to overwinter (Figure 28) (Muto et al. 2019).

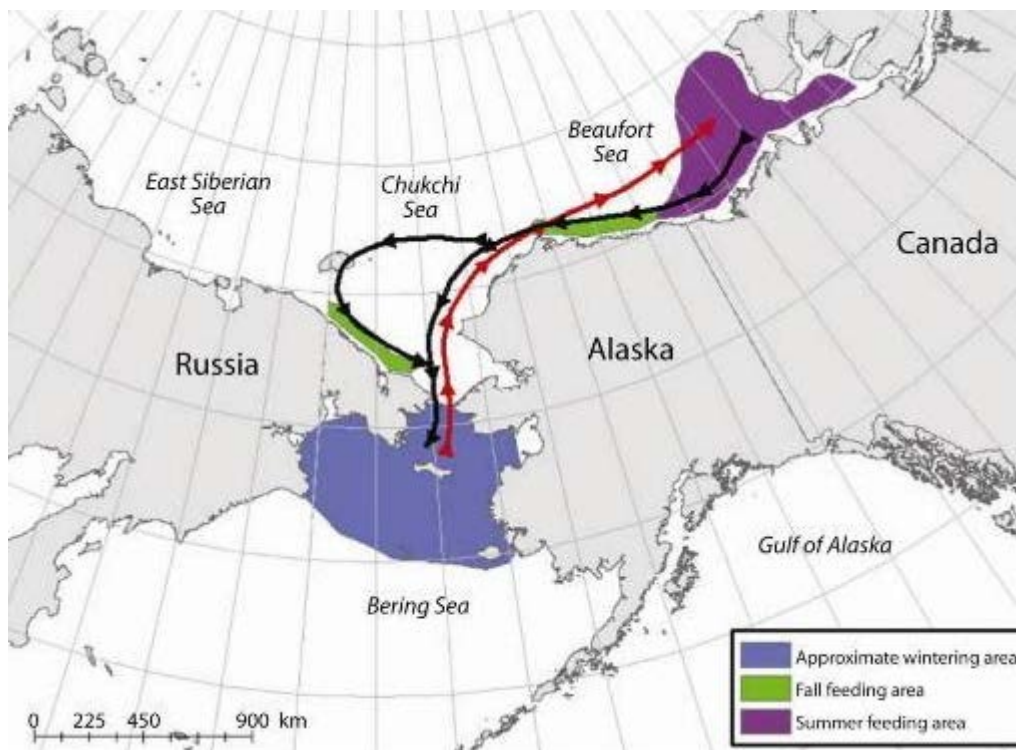


Figure 28. Generalized migration route, feeding areas, and wintering area for Western Arctic bowhead whale (Moore et al. 2006).

Occurrence in the Action Area

The vast majority of the bowhead population migrate to the Bering Sea during the fall and do not return eastwards through the Beaufort Sea again until the spring. During the eastward (spring) migration, the whales are distributed far offshore. While a few whales may occur in the Central Beaufort Sea area throughout the summer, most of the population spend the summer in the eastern Beaufort Sea before passing through again during the latter part of summer and fall as bowheads migrate west to over winter in the Bering Sea. Bowhead whales are most likely to be encountered during the fall migration when they travel closer to shore (than during the spring migration) in water ranging from 15 to 200 m deep (50 to 656 ft) (Clarke et al. 2012; Miller et al.

2002). The fall migration trajectory varies annually and is influenced by ice presence (Moore and Reeves 1993). Treacy et al. (2006) found that the main migration corridor for bowhead whales during the fall migration was 73.4 km (46 mi) offshore in years of heavy ice conditions, 49.3 km (31 mi) offshore during moderate ice conditions, and 31.2 km (19 mi) off shore during light ice conditions.

Clarke et al. (2015b) evaluated biologically important areas (BIAs) for bowheads in the U.S. Arctic region and identified nine BIAs. The spring (April-May) migratory corridor BIA for bowheads is far offshore of Prudhoe Bay and West Dock but within the transit portion of the action area, while the fall (September-October) migratory corridor BIA (western Beaufort on and north of the shelf) for bowheads is further inshore and closer to Prudhoe Bay and within the transit, noise, and spill portions of the action area (Figure 29). Clarke et al. (2015b) also identified four BIAs for bowheads that are important for reproduction and encompassed areas where the majority of bowhead whales identified as calves were observed each season; none of these reproductive BIAs overlap with Prudhoe Bay and West Dock, but may be encompassed in the transit, noise, and spill portions of the action area (Figure 30). Finally, three bowhead feeding BIAs were identified (Clarke et al. 2015b). Only the September-October feeding BIA (bowheads feeding on the western Beaufort continental shelf, out to approximately the 50-m isobaths) is near Prudhoe Bay and West Dock, but it does not overlap with the action area (Figure 31). However, the fall feeding BIA may overlap with potential transit, noise, or spill portions of the action area (Figure 31).

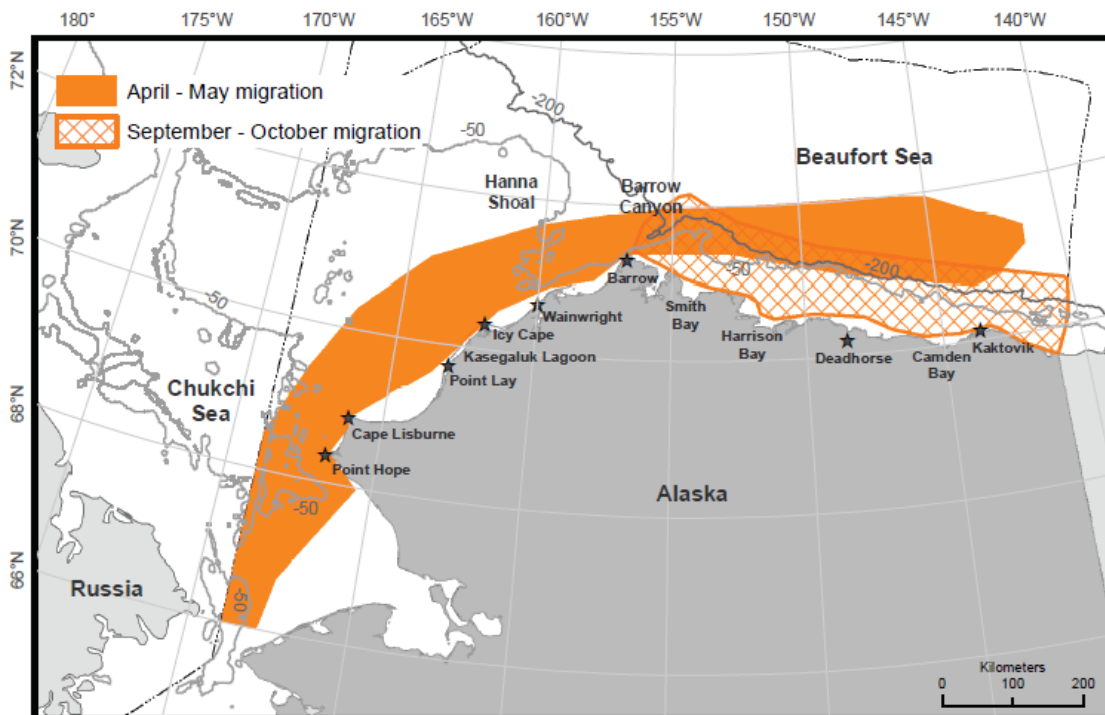


Figure 29. Bowhead whale migratory corridor BIAs for spring (April-May) and fall (September-October), determined from aerial- and ice-based surveys, satellite telemetry, and passive acoustic monitoring; also shown are the 50- and 200-m depth contours. (Clarke et al. 2015b, Figure 8.3)

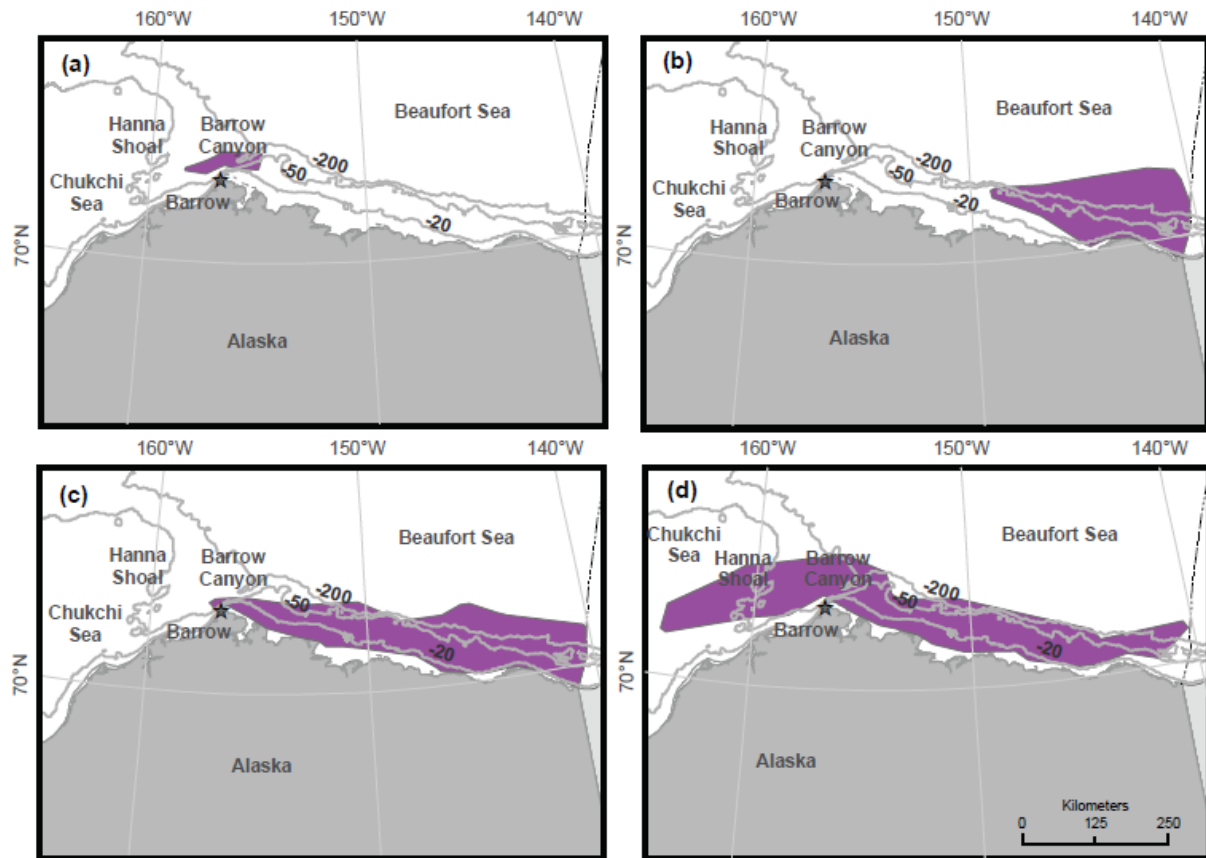


Figure 30. Bowhead whale reproduction BIAIs during (a) spring and early summer (April through early June); (b) summer (July and August); and fall (c) September and (d) October, determined from calf sightings collected during aerial- and ice-based surveys. Also shown are the 20-, 50-, and 200-m depth contours (Clarke et al. 2015b, Figure 8.1).

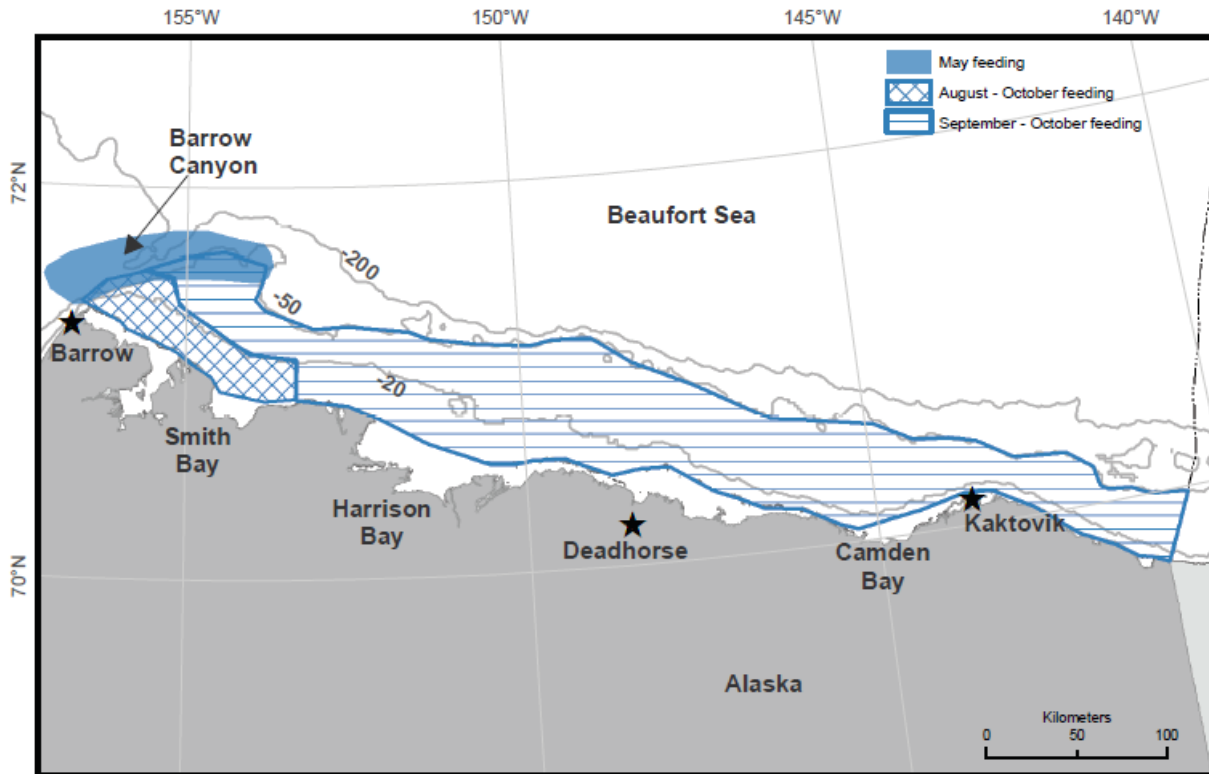


Figure 31. Bowhead whale feeding BIAs identified during the eastward spring migration in May near Barrow Canyon; from Smith Bay to Point Barrow in August through October, generally shoreward of the 20-m isobaths; and during the westward fall migration from September through October, generally shoreward of the 50-m isobath. BIAs were determined using aerial survey data. Also shown are the 20-, 50-, and 200-m depth contours (Clarke et al. 2015b, Figure 8.2).

Ferguson et al. (2015a) identified similar bowhead migratory corridor and feeding BIAs in the Bering Sea (Figure 32 and Figure 33, respectively). While the two feeding BIAs around St. Lawrence Island are not likely to intersect with the transit portion of the action area (unless vessels need to unexpectedly change course, Figure 33), the migratory corridor BIA overlaps with the marine transit route through the Bering Strait (Figure 32).

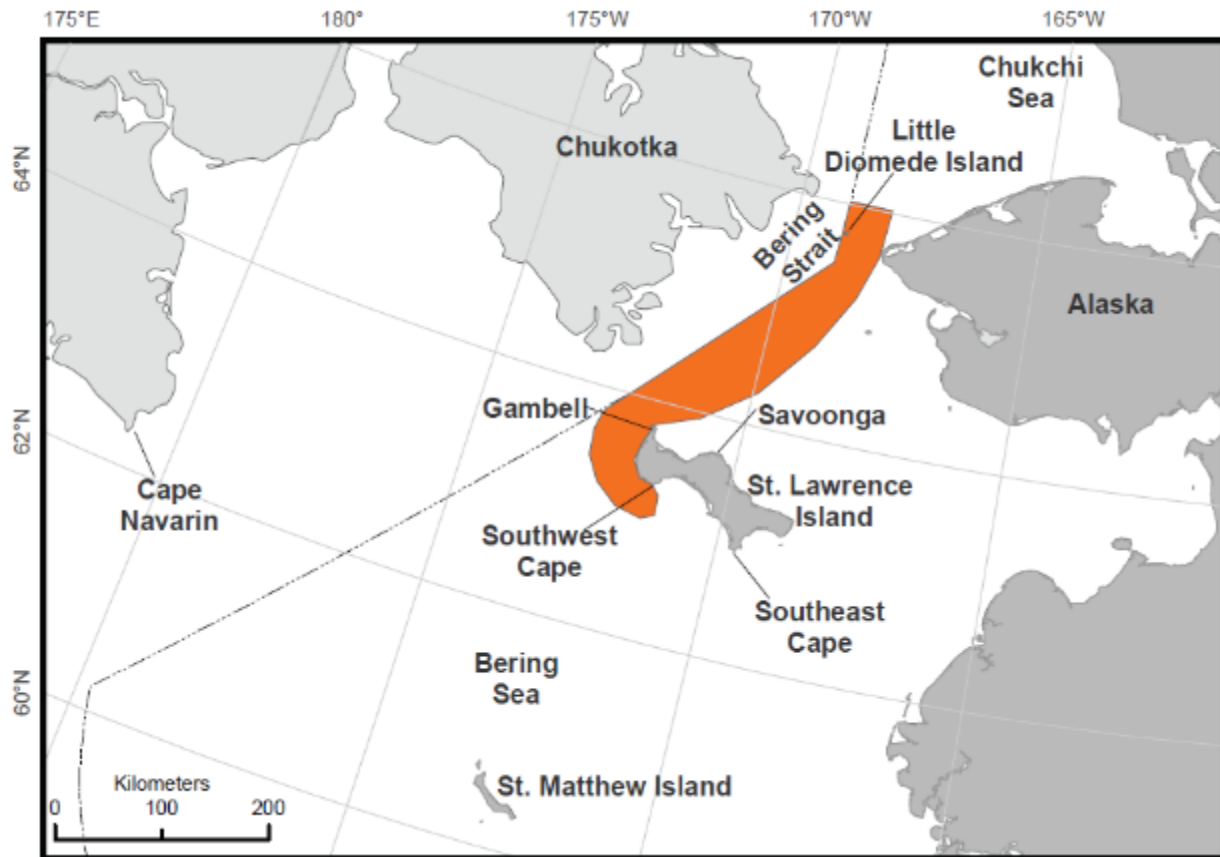


Figure 32. Bowhead whale BIA for the spring (northbound) migratory corridor through the Bering Sea; highest densities are from March through June, substantiated through aerial surveys, traditional ecological knowledge, and satellite-tagging data (Ferguson et al. 2015a, Figure 7.2).

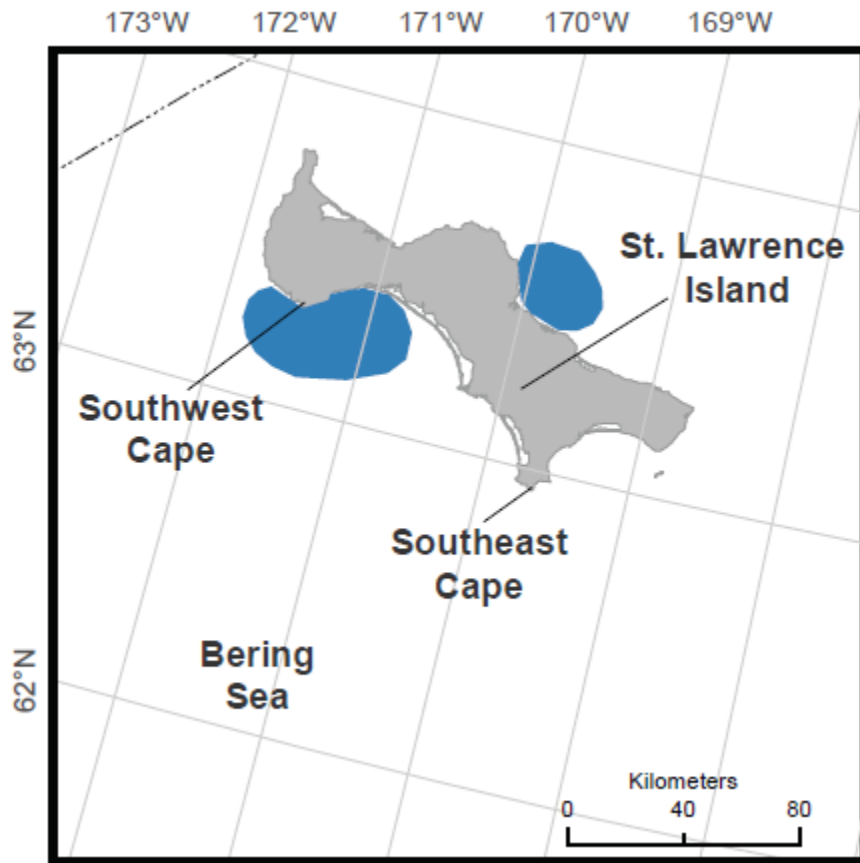


Figure 33. Bowhead whale feeding Biologically Important Area (BIA) near St. Lawrence Island, substantiated through traditional ecological knowledge, stomach content analysis, and satellite-tagging data. Highest densities of bowhead whales occur in these areas from November through April. (Ferguson et al 2015a, Figure 7.1)

Satellite tracking studies since 2006 indicate that bowhead whales were generally present in the Alaskan Beaufort Sea between April and October (Figure 34 through Figure 40). Locations within a specific localized area that showed a “zig-zag” movement pattern were classified as being associated with lingering behavior, which was inferred to be feeding (Quakenbush 2018). In April and May, whales migrated east past Prudhoe Bay in route to Amundsen Gulf and the Cape Bathurst Polynya (Figure 34 and Figure 35). At this time, whales were typically north of the shelf break, which is approximately 70 km (43 mi) north of West Dock (Quakenbush 2018). Some whales return to the Alaskan Beaufort Sea in June and July (Figure 36 and Figure 37), prior to the main migration in September and October. Many (but not all) of these movements also occurred north of the shelf break.

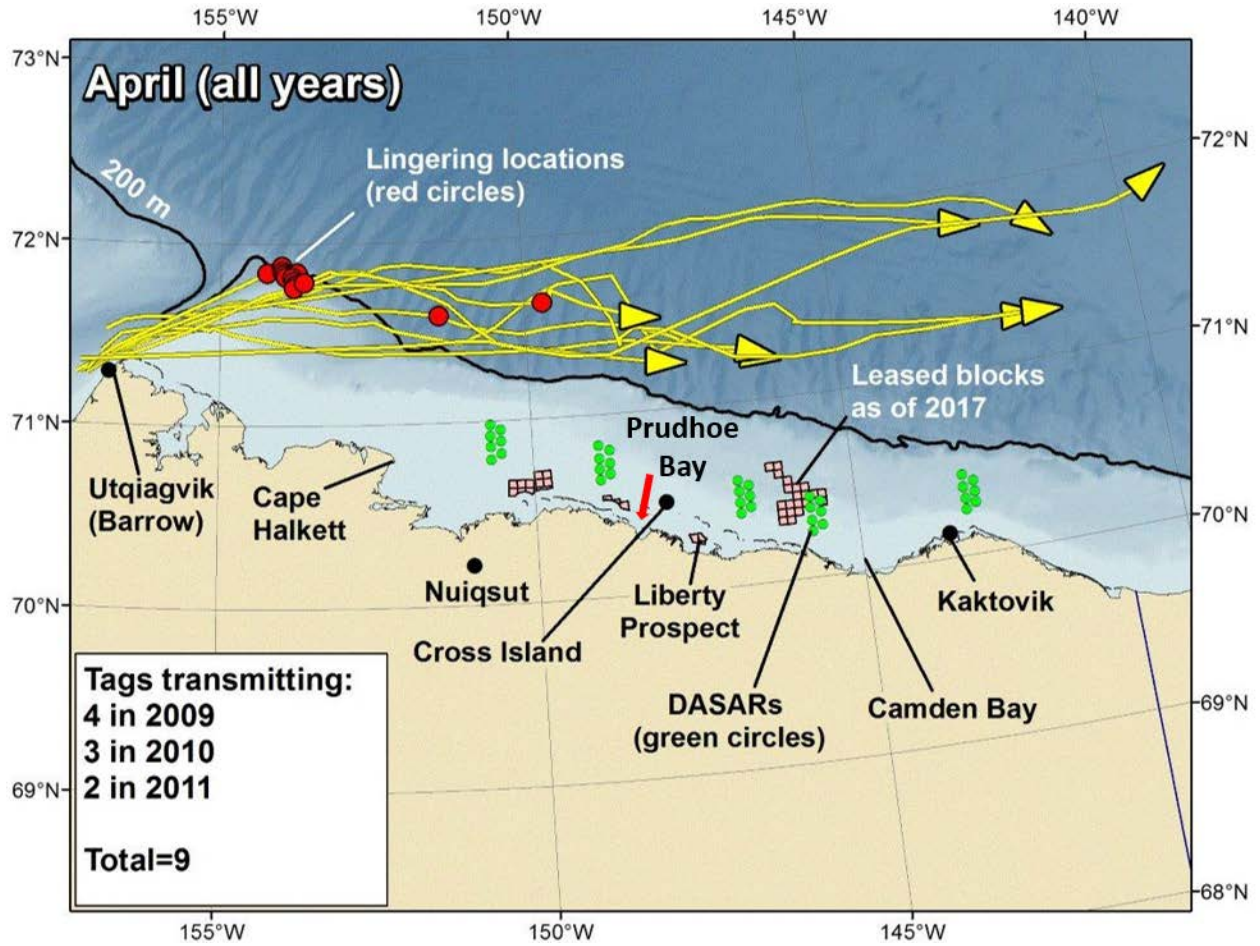


Figure 34. Tracks of satellite tagged bowhead whales during April off the North Slope of Alaska (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

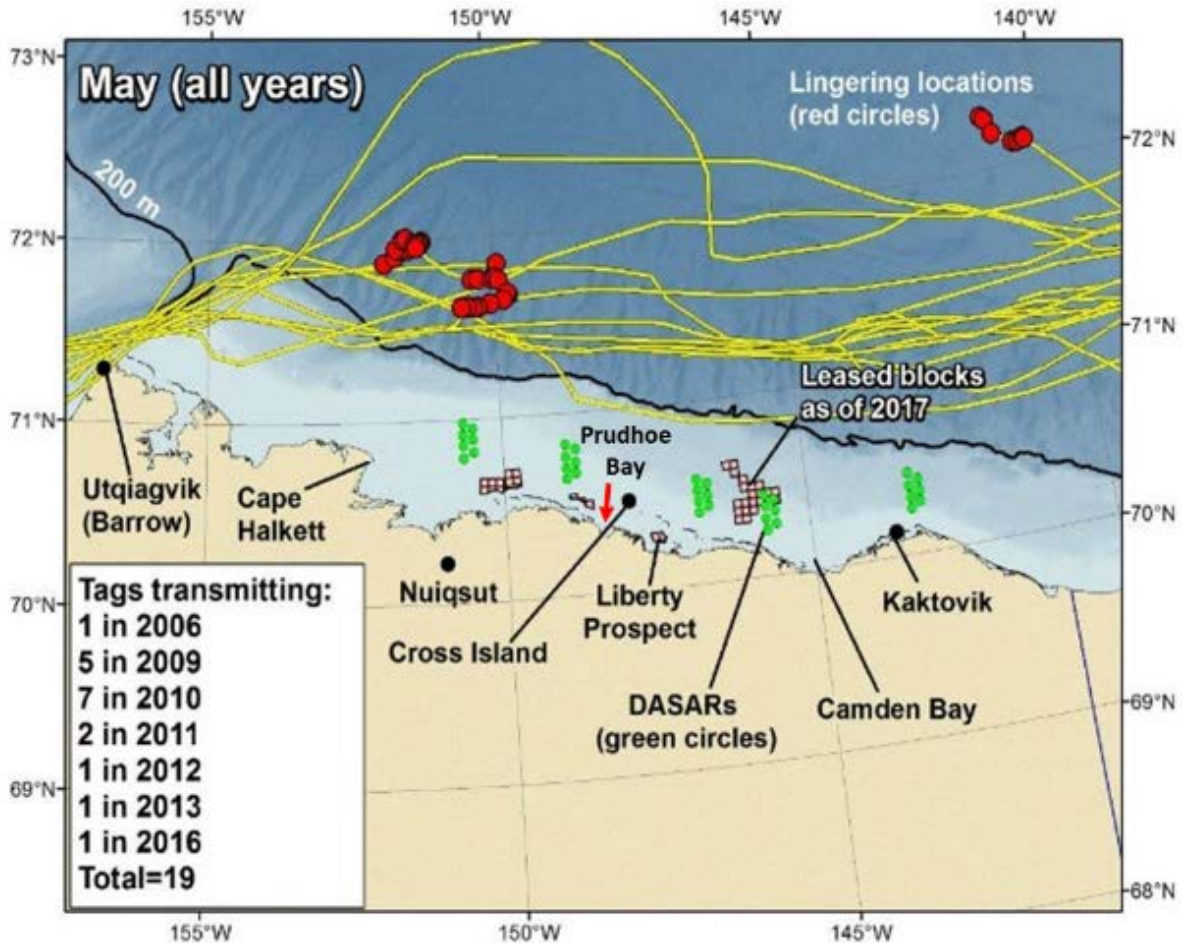


Figure 35. Tracks of satellite tagged bowhead whales during May off the North Slope (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

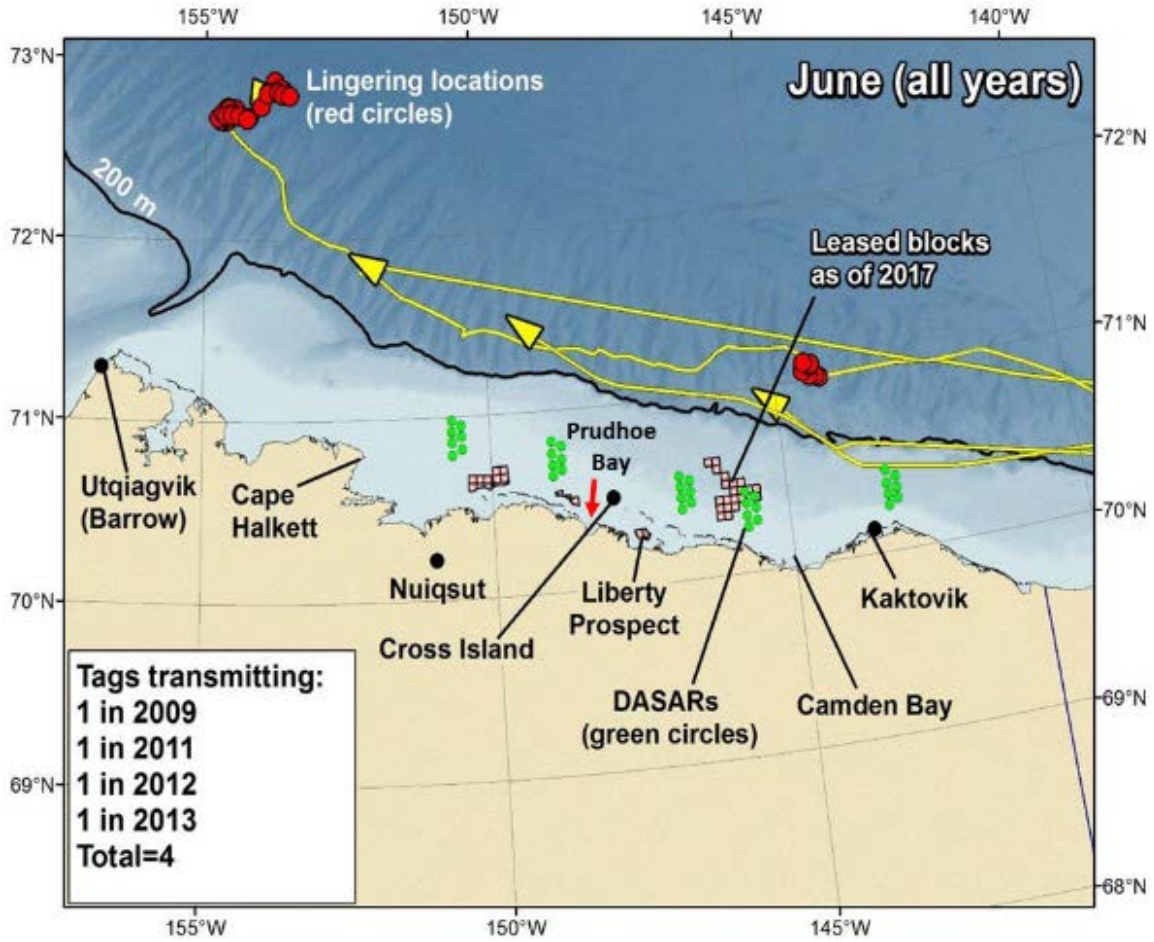


Figure 36. Tracks of satellite tagged bowhead whales during June off the North Slope of Alaska (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

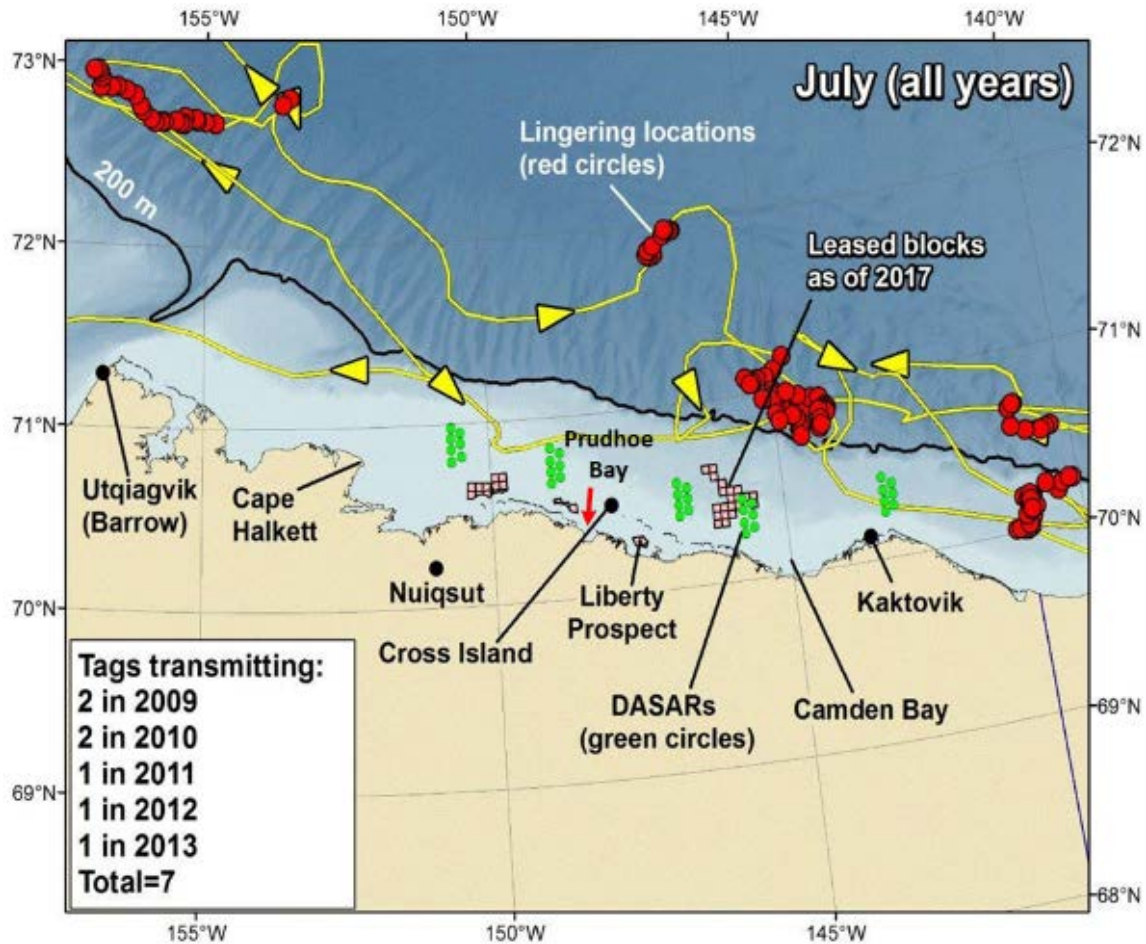


Figure 37. Tracks of satellite tagged bowhead whales during July off the North Slope of Alaska (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

Tagged whales first began making inshore movements in August (Figure 38). A whale passed within 16 km (10 mi) of the coast in August of 2016. Movements of tagged bowhead whales tended to be outside of the barrier islands in September and October (Figure 39 and Figure 40). Although tagged whales may have migrated inshore of the barrier islands (between successful satellite uplinks), the large majority of movements appeared to be outside the barrier islands. The main fall migratory corridor for tagged whales extended approximately 40 km (25 mi) north from the barrier islands (Quakenbush 2018).

Quakenbush (2018) did not identify lingering locations (i.e., inferred feeding locations) for tagged whales that were closer than 30 km (19 mi) from the coast. One whale paused its migration in September of 2010 for a single 6-hour interval, approximately 30 km (19 mi) east-northeast of the coast. This does not mean that whales may not sometimes feed closer to the coast. However, the main feeding area in the Alaskan Beaufort Sea is west of Cape Halkett (approximately 180 km [112 mi] west of Prudhoe Bay). Tagged bowhead data also showed limited feeding behavior in Camden Bay (approximately 10 km [6.2 mi] east of Prudhoe Bay), where one whale lingered for four days and another lingered for nine days in 2010 (Quakenbush 2018). Migrating (i.e. non-feeding) bowhead whales spent an average of 2 days in the Prudhoe

Bay area (Quakenbush et al. 2013). There have been no locations of tagged bowhead whales east of Cape Halkett later than October. Although movements of tagged animals do not likely represent movements of the entire population, they do indicate that bowhead whales are in the Prudhoe Bay area in summer and fall (Quakenbush 2018).

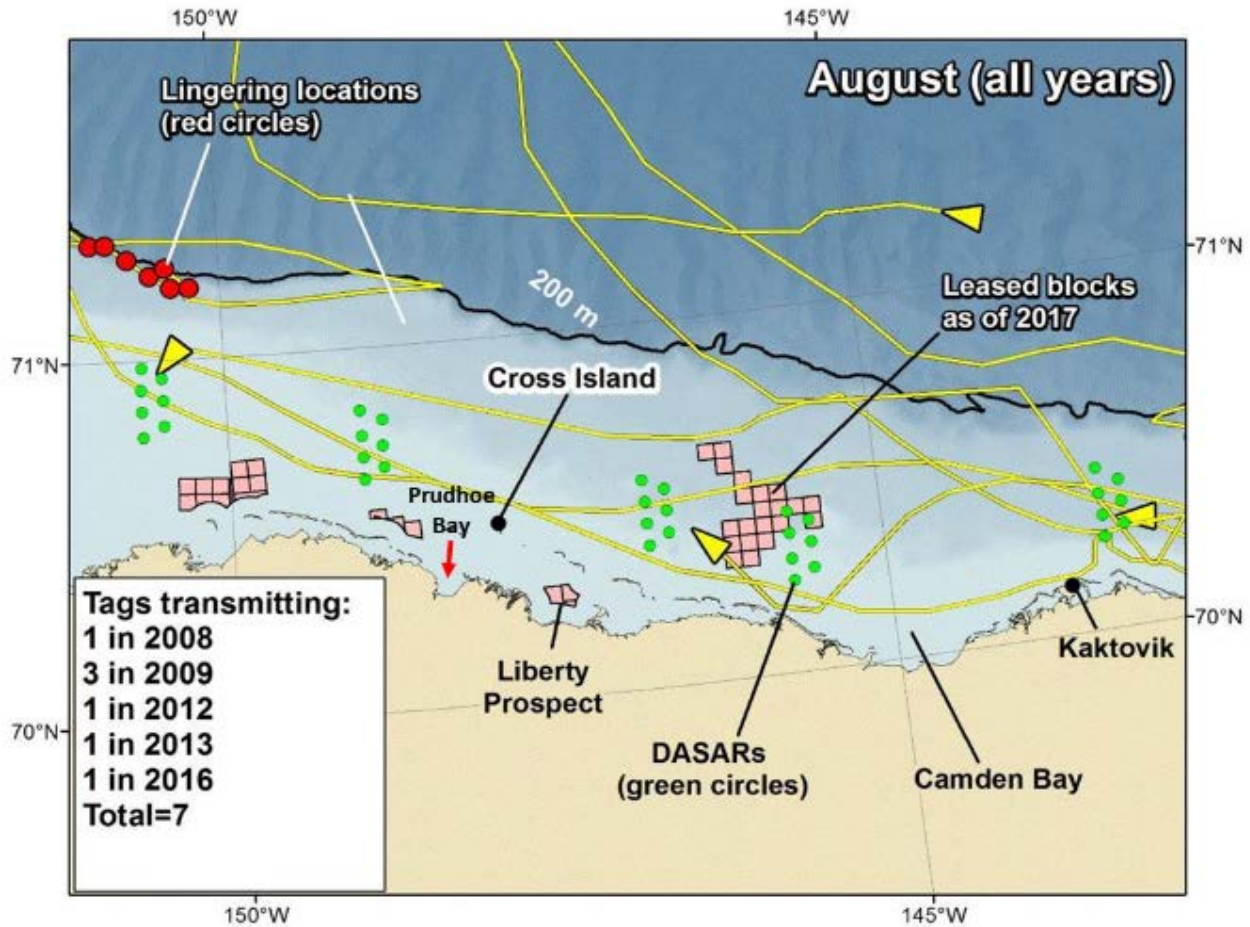


Figure 38. Tracks of satellite tagged bowhead whales during August off the North Slope of Alaska (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

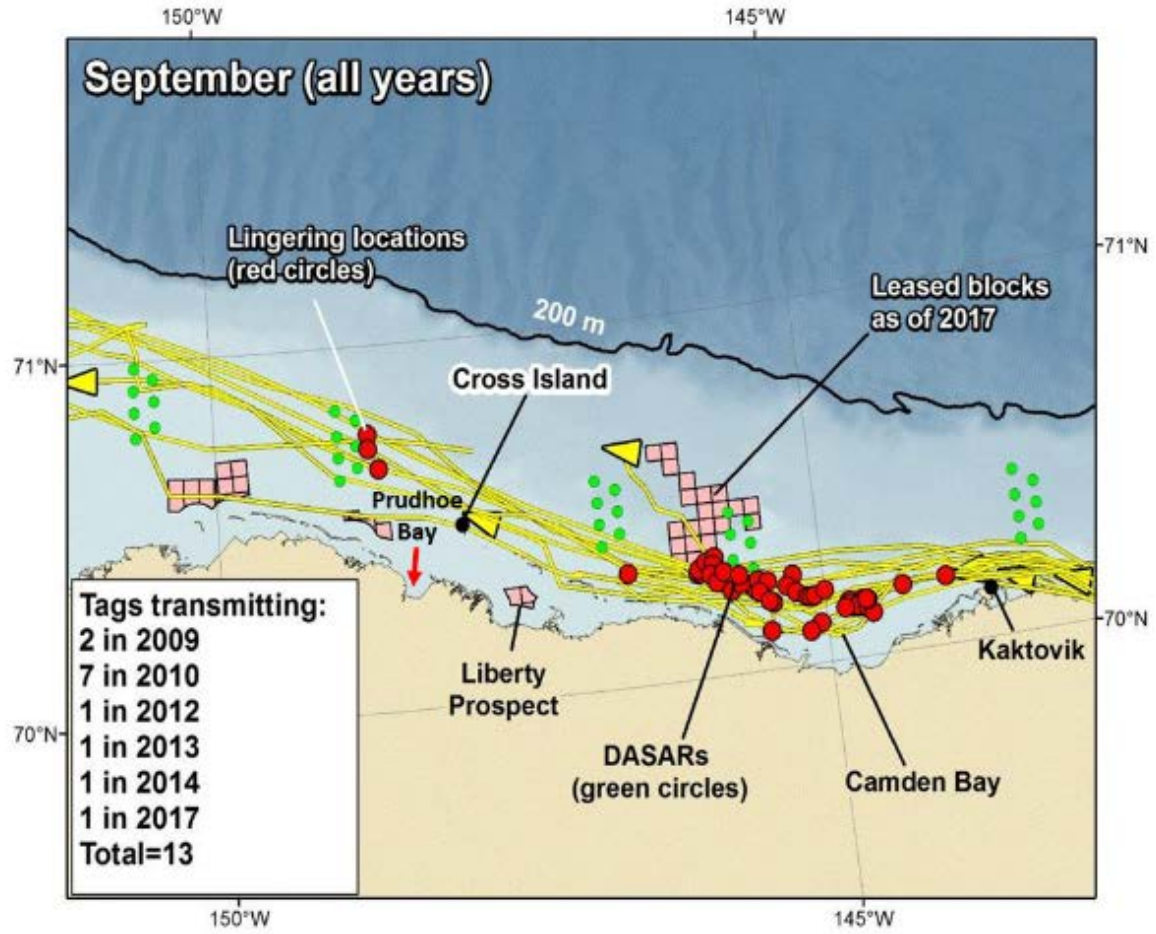


Figure 39. Tracks of satellite tagged bowhead whales during September off the North Slope of Alaska. (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

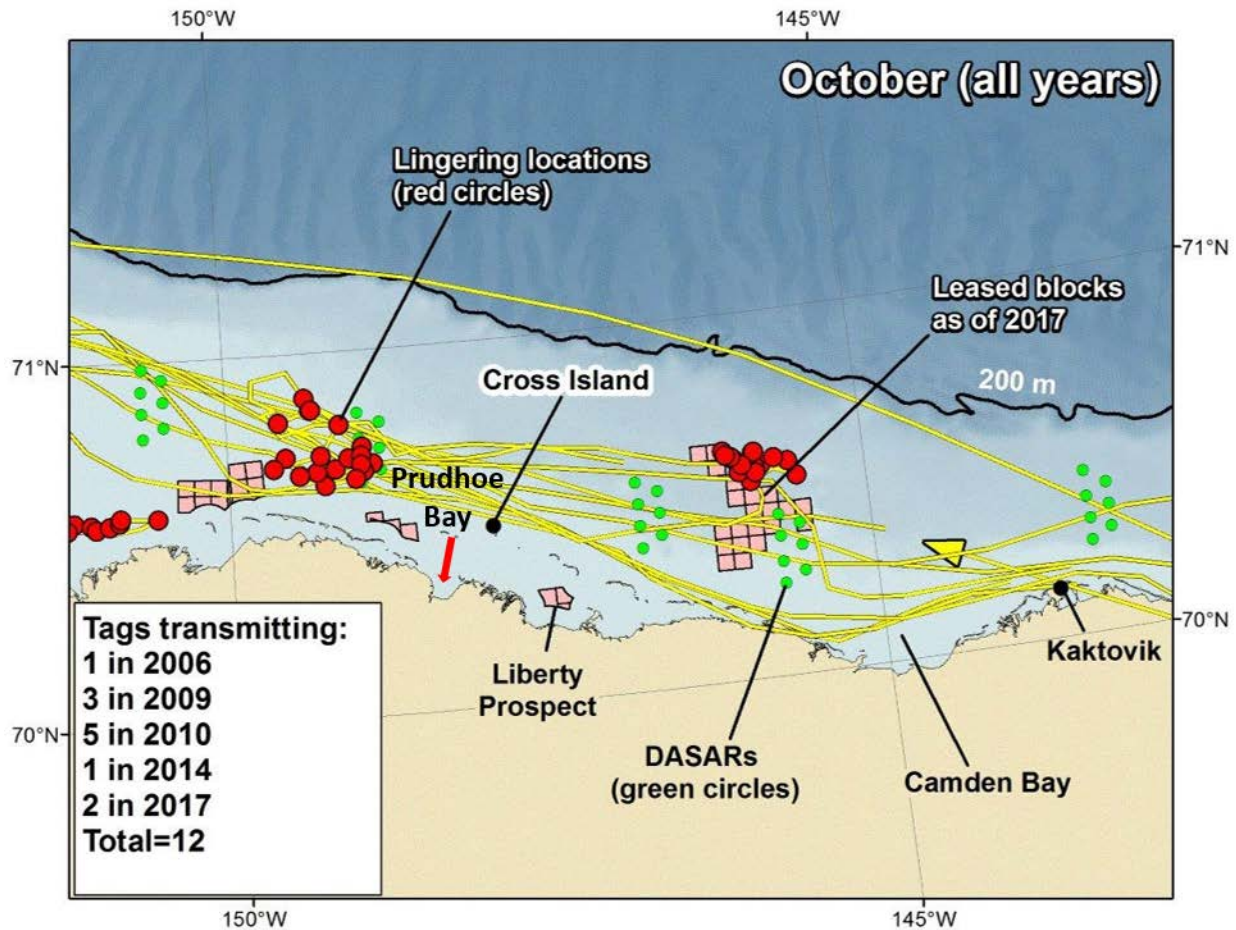


Figure 40. Tracks of satellite tagged bowhead whales during October off the North Slope of Alaska (Quakenbush 2018). The location of Prudhoe Bay is indicated by the red arrow.

During summer seismic surveys conducted in nearby Foggy Island Bay (east of Prudhoe Bay) in 2008, only one cetacean sighting was documented by Protected Species Observers (PSO) shoreward of the barrier islands. This sighting was of a mixed group of eight bowhead and gray whales southwest of Narwhal Island (Aerts et al. 2008). However, no bowhead whales were observed by PSOs during recent shallow hazards surveys conducted in Foggy Island Bay (Cate et al. 2015 ; Smultea et al. 2014). From 2001 through 2004, 95 percent of bowhead whales detected during fall acoustic monitoring at Northstar were located 8.4 to 14.2 km (5.2 to 8.8 mi) offshore beyond the barrier islands (Blackwell et al. 2007).

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project is a continuation of the Bowhead Whale Aerial Survey Project and Chukchi Offshore Monitoring in Drilling Area marine mammal aerial survey project. Through these projects, aerial surveys have been conducted in the Alaska Beaufort Sea in late summer and autumn since 1979 (Clarke et al. 2015a; Clarke et al. 2012; Ljungblad et al. 1987; Ljungblad et al. 1986; Monnett and Treacy 2005; Treacy et al. 2006). Before 2016, the ASAMM study area did not include waters inside the barrier islands near the coast. Figure 41 displays sightings of bowhead whales near the coast from 2009-2017 and Figure 42 displays sightings in 2018. The ASAMM database and annual

reports are available from the NMFS Marine Mammal Laboratory web page:
<http://www.afsc.noaa.gov/NMML/cetacean/>.

As mentioned, during the ice-covered season (winter and spring) bowhead whales will not be present at or near Prudhoe Bay. Summer and fall bowhead whale densities were calculated using the results from ASAMM surveys from 2011 through 2015. The surveys provided sightings and effort data by month and season (summer and fall), as well as each survey block (Clarke et al. 2015a; Clarke et al. 2017; Clarke et al. 2012; Clarke et al. 2013). While none of the effort and sighting data reported in the aerial survey reports from surveys conducted in 2011 through 2015 included Prudhoe Bay due to its more inshore location within the barrier islands, we followed the approach used in previous consultations nearby (e.g., Liberty DPP) and selected only on-transect effort and sighting data from Survey Block 1 of the ASAMM survey.

Bowhead whale densities were calculated in a two-step approach; first a sighting rate of whales per km was calculated, then they multiplied the transect length by the effective strip width using the modeled species-specific effective strip width for an aero commander aircraft calculated by (Ferguson and Clarke 2013). Where the effective strip width is the half-strip width it must be multiplied by 2 in order to encompass both sides of the transect line. Thus whale density was calculated as follows:

$$\text{Whales per km}^2 = \text{sightings per kilometer} / (2 \times \text{the effective strip width})$$

The effective strip width for bowhead whales was calculated to be 1.15 km (CV = 0.08). Table 31 outlines the information used to determine summer and fall densities of bowhead whales. These density estimates are expected to be overestimates for the Prudhoe Bay area as bowhead whales rarely occur within the barrier islands, instead preferring to migrate north of the barrier islands.

Table 31. ASAMM survey results for bowhead whales from 2011-2018

Year	Summer (Jul-Aug)				Fall (Sept-Oct)				
	On-Transect Effort (km)	On-Transect Sightings	Sighting Rate	Density	On-Transect Effort (km)	On-Transect Sightings	Sighting Rate	Density	
2011	346	1	0.002890	0.001257	1130	24	0.021239	0.009234	
2012	1493	5	0.003349	0.001456	1696	17	0.010024	0.004358	
2013	1582	21	0.013274	0.005771	1121	21	0.018733	0.008145	
2014	1393	17	0.012204	0.005306	1538	79	0.051365	0.022333	
2015	1262	15	0.011886	0.005168	1663	17	0.010222	0.004444	
2016	1914	97	0.050679	0.022034	2360	23	0.009746	0.004237	
2017	3003	8	0.002664	0.001158	1803	255	0.141431	0.061492	
2018	2491	2	0.000803	0.000349	1535	69	0.044951	0.019544	
Encounter Rate				0.012311	Encounter Rate				0.039312
Density				0.005353	Density				0.017092

Aerial Surveys of Arctic Marine Mammals

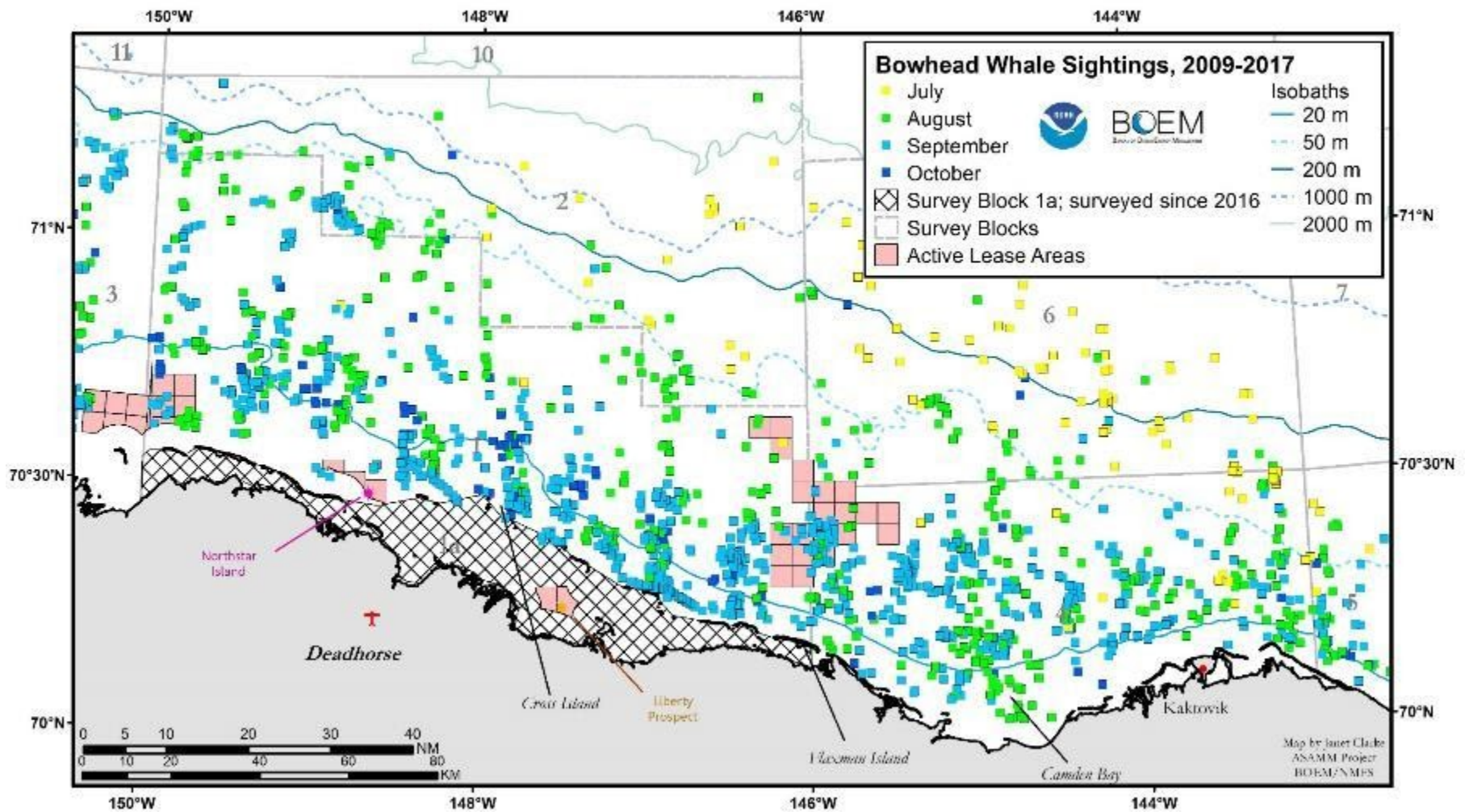


Figure 41. Bowhead whale sightings from Aerial Surveys of Arctic Marine Mammals (ASAMM), 2009–2017 (Clarke 2018)

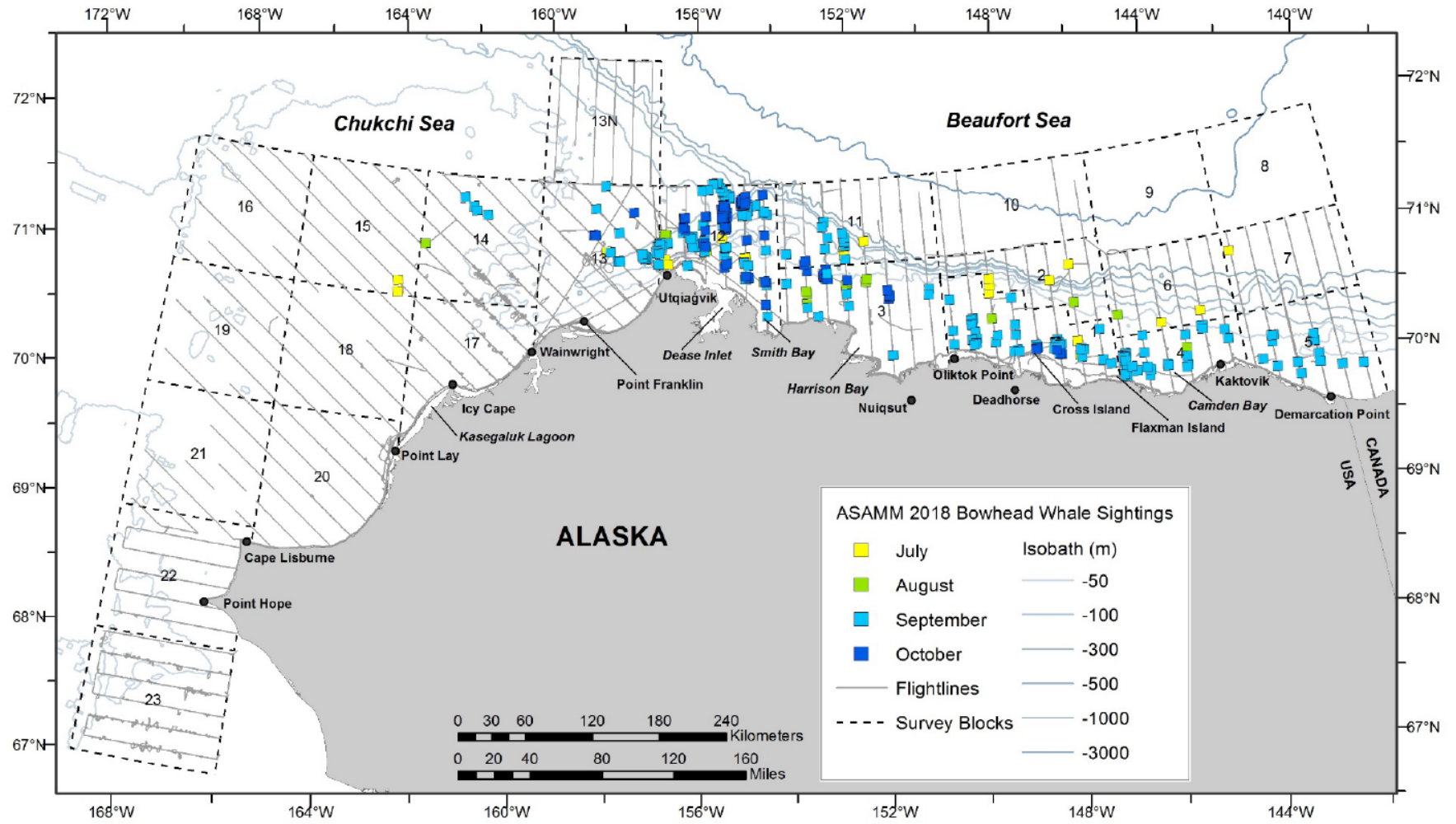


Figure 42. ASAMM bowhead whale sightings, 2018 (from <https://www.fisheries.noaa.gov/alaska/science-data/alaska-fisheries-science-center-surveys-arctic-2019-preliminary-findings#aerial-survey-of-arctic-marine-mammals>)

Feeding and Prey Selection

Evidence suggests that bowhead whales feed on concentrations of zooplankton throughout their range (Muto et al. 2019). Bowheads are filter feeders, straining prey from the water through baleen (Lowry 1993). They feed throughout the water column, including bottom feeding as well as skim feeding near the surface (Würsig et al. 1989). Skim feeding can occur when animals are alone or may occur in coordinated echelon formations of over a dozen animals (Würsig et al. 1989). Bowhead whales typically spend a high proportion of time on or near the ocean floor. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush et al. 2010). Laidre et al. (2007) and others have identified krill concentrated near the sea bottom, and bowhead whales have been observed with mud on their heads and bodies and streaming from their mouths (Mocklin 2009). Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods (Lowry et al. 2004; Moore et al. 2010). Euphausiids and copepods are thought to be their primary prey. Lowry et al. (2004) documented that other crustaceans and fish also were eaten but were minor components in samples consisting mostly of copepods or euphausiids.

Concentrations of zooplankton appear necessary for bowhead whales and other baleen whales to feed efficiently to meet energy requirements (Kenney et al. 1986; Lowry 1993). It is estimated that a 60 ton bowhead whale eats 1.5 ton of krill each day. Estimated rate of consumption is 50,000 individual copepods, each weighing about 0.004 g, per minute of feeding time (BOEM 2011).

Western Arctic bowhead whales feed in the outer continental shelf of the Chukchi and Beaufort Seas with level of use varying among years, among individuals, and among areas. It is likely that bowheads feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea.

Hearing, Vocalizations, and Other Sensory Abilities

Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). Most underwater calls are at a fairly low frequency and easily audible to the human ear. Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead whale songs have a bandwidth of 20 to 5000 Hz with the dominant frequency at approximately 500 Hz and duration lasting from 1 minute to hours. Pulsive vocalizations range between 25 and 3,500 Hz and lasts 0.3 to 7.2 seconds (Erbe 2002; George et al. 2004; Würsig and Clark 1993).

NMFS categorizes bowhead whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group, with an estimated hearing range of 7 Hz to 35 kHz (NMFS 2018c). Inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz and 5 kHz, with maximum sensitivity between 100 Hz and 500 Hz (Erbe 2002).

Bowhead whales have well-developed capabilities for navigation and survival in sea ice. Bowhead whales are thought to use the reverberations of their calls off the undersides of ice floes to help them orient and navigate (Ellison et al. 1987; George et al. 1989). This species is well adapted to ice-covered waters and can easily move through extensive areas of nearly solid sea ice

cover (Citta et al. 2012). Their skull morphology allows them to break through ice up to 18 cm thick to breathe in ice covered waters (George et al. 1989).

Bowhead whales appear to have good lateral vision. Recognizing this, whalers approach bowheads from the front or from behind, rather than from the side (Rexford 1997). In addition, whalers wear white parkas on the ice so that they are not visible to the whales when they surface (Noongwook et al. 2007b; Rexford 1997).

Olfaction may also be important to bowhead whales. Recent research on the olfactory bulb and olfactory receptor genes suggests that bowheads not only have a sense of smell but one better developed than in humans (Thewissen et al. 2011). The authors speculated that bowheads may use their sense of smell to find dense aggregations of krill to prey upon.

4.3.2 Bearded seal

Status and Population Structure

There are two recognized subspecies of the bearded seal: *E. b. barbatus*, often described as inhabiting the Atlantic sector (Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay; (Rice 1998)); and *E. b. nauticus*, which inhabits the Pacific sector (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas; (Heptner et al. 1976; Manning 1974; Ognev 1935; Scheffer 1958). Based on evidence for discreteness and ecological uniqueness, NMFS concluded that the *E. b. nauticus* subspecies consists of two DPSs—the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, encompassing the remainder of the range of this subspecies (75 FR 77496; December 10, 2010). Only the Beringia DPS is found in U.S. waters (and the action area), and this portion is recognized by NMFS as a single Alaska stock. NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740).

A reliable population estimate for the entire Alaska stock is not available, but research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but for the U.S. portion of the Bering Sea, Boveng et al. (2017) reported model-averaged abundance estimates of 170,000 and 125,000 bearded seals in 2012 and 2013, respectively. These results reflect use of an estimate of availability (haulout correction factor) based on data from previously deployed satellite tags. The authors suggested that the difference in seal density between years may reflect differences in the numbers of bearded seals using Russian versus U.S. waters between years, and they noted that if this was the case, the eventual development of comprehensive estimates of abundance for bearded seals in the Bering Sea that incorporate data in Russian waters may show less difference between years.

In September 2019, NMFS declared an Unusual Mortality Event (UME) for ice seals, recognized to have started on June 1, 2018. From the start date through April 15, 2020, the NMFS Standing Network had reports of 84 bearded seals (and 85 unidentified seals, some of which may have been bearded seals). This UME is currently ongoing and the cause, or causes, of these deaths is

currently being investigated by NMFS.

Distribution

The Beringia DPS of the bearded seal includes all bearded seals from breeding populations in the Arctic Ocean and adjacent seas in the Pacific Ocean between 145°E longitude in the East Siberian Sea and 130°W longitude in the Canadian Beaufort Sea, except west of 157°W longitude in the Bering Sea and west of the Kamchatka Peninsula (where the Okhotsk DPS is found). The bearded seal's effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters. (Cameron et al. 2010) defined the core distribution of bearded seals as those areas of known extent that are in waters less than 500 m (1,640 ft) deep.

Bearded seals are closely associated with sea ice, particularly during the critical life history periods related to reproduction and molting, and can be found in a broad range of ice types. They generally prefer moving ice that produces natural openings and areas of open-water (Fedoseev 1984; Heptner et al. 1976; Nelson et al. 1984). They usually avoid areas of continuous, thick, shorefast ice and are rarely seen in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Burns 1981; Burns and Frost 1979; Burns and Harbo 1972; Fedoseev 1965; Fedoseev 1984; Nelson et al. 1984; Smith 1981). Within the U.S. range of the Beringia DPS, the extent of favorable ice conditions for bearded seals is most restricted in the Beaufort Sea, where there is a relatively narrow shelf with suitable water depths. In comparison, suitable ice conditions and water depths occur in limited areas of the Chukchi Sea, and over much broader areas in the Bering Sea (Burns 1981). During winter, the central and northern parts of the Bering Sea shelf, where heavier pack ice occurs, have the highest densities of adult bearded seals (Burns 1981; Burns and Frost 1979; Cameron et al. 2018; Heptner et al. 1976; Nelson et al. 1984), possibly reflecting the favorable ice conditions there. In contrast, Cameron et al. (2018) found that young bearded seals were closely associated with the ice edge farther south in the Bering Sea.

Spring surveys conducted in 1999 through 2000 along the Alaska coast of the Chukchi Sea, and in 2001 near St. Lawrence Island, indicated that bearded seals tended to prefer areas of between 70 and 90 percent ice coverage, and were typically more abundant in offshore pack ice 37 to 185 km (20 to 100 nautical miles [nm]) from shore than within 37 km (20 nm) from shore, except for high concentrations nearshore to the south of Kivalina (Bengtson et al. 2005; Simpkins et al. 2003).

It is thought that in the fall and winter most bearded seals move south with the advancing ice edge through Bering Strait into the Bering Sea where they spend the winter, and in the spring and early summer, as the sea ice melts, many of these seals move north through the Bering Strait into the Chukchi and Beaufort Seas (Burns 1967; Burns 1981; Burns and Frost 1979; Cameron and Boveng 2007; Cameron and Boveng 2009; Cameron et al. 2018). However, bearded seal vocalizations have been recorded year-round in the Chukchi and Beaufort Seas (MacIntyre et al. 2013; MacIntyre et al. 2015), indicating some unknown proportion of the population occurs there over winter. The overall summer distribution is quite broad, with seals rarely hauled out on land (Burns 1967, Heptner et al. 1976a, Burns 1981, Nelson et al. 1984). However some seals, mostly juveniles, have been observed hauled out on land along lagoons and rivers in some areas of Alaska, such as in Norton Bay (Huntington 2000a), near Wainwright (Nelson 1981), and on

sandy islands near Barrow (now Utqiagvik)(Cameron et al. 2010).

Occurrence in the Action Area

Bearded seals are expected to be present along the marine transit route through the Bering, Chukchi, and Beaufort Seas, and near the pile-driving activities in Prudhoe Bay. During the open-water period when the majority of the AK LNG activities will occur, the Beaufort Sea likely supports fewer bearded seals than the Chukchi Sea because of the more extensive foraging habitat available to bearded seals in the Chukchi Sea. In addition, as a result of shallow waters, the sea floor in Prudhoe Bay south of the barrier islands is often scoured by ice, which limits the presence of bearded seal prey species. Nevertheless, aerial and vessel-based surveys associated with seismic programs, barging, and government surveys in nearby Foggy Island Bay between 2005 and 2010 reported several bearded seal sightings (Funk et al. 2008; Green et al. 2007; Green and Negri 2005; Green and Negri 2006; Hauser et al. 2008; Reiser et al. 2011; Savarese et al. 2010). In addition, eight bearded seal sightings were documented during shallow geohazard seismic and seabed mapping surveys conducted in July and August 2014 (Smultea et al. 2014). Frouin-Mouy et al. (2016) conducted acoustic monitoring in Foggy Island Bay from early July to late September 2014, and detected pinniped vocalizations on 10 days via the nearshore recorder and on 66 days via the recorder farther offshore. Although the majority of these detections were unidentified pinnipeds, bearded seal vocalizations were positively identified on two days (Frouin-Mouy et al. 2016).

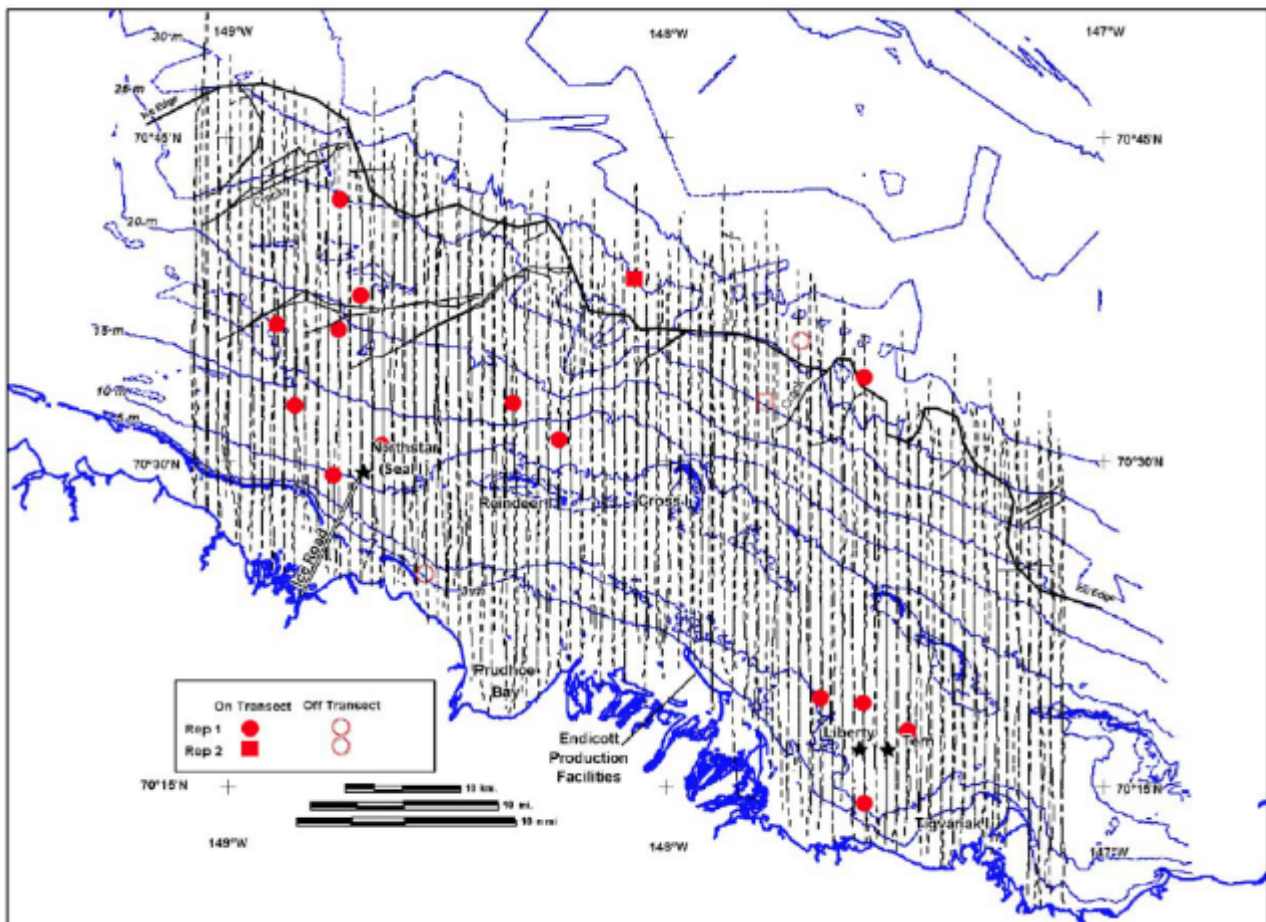
Although bearded seal vocalizations (produced by adult males) have been recorded nearly year-round in the Beaufort Sea (MacIntyre et al. 2013, MacIntyre et al. 2015), most bearded seals overwinter in the Bering Sea. In addition, during late winter and early spring, Prudhoe Bay is covered with shorefast ice and the nearest lead systems are at least several kilometers away, making the area unsuitable habitat for bearded seals. Therefore, bearded seals are not expected to be encountered in or near the Prudhoe Bay area during late winter through early spring.

At present, there is no official population estimate for bearded seals occupying the Beaufort Sea, particularly in the coastal areas during the winter and spring. Industry monitoring surveys for the Northstar development (approximately 18km northwest of Prudhoe Bay) during the spring seasons in 1999–2002 (Moulton et al. 2002a; Moulton et al. 2001; Moulton et al. 2003; Moulton et al. 2000) counted 47 bearded seals (annual mean of 11.75 seals during an annual mean of 3,997.5 km² of effort, Table 32), and while the numbers were deemed too low to calculate a reliable density estimate in each year, no other data on bearded seal presence were available.

Table 32. Summary of available data on bearded seal sightings in and around Northstar development during spring from 1999-2002

Year	Number of Sightings	Effort (km ²)	Bearded (Seals/km ²)	Source
1999	20	3,980	0.005	(Moulton et al. 2000)
2000	15	4,245	0.004	(Moulton et al. 2001)
2001	3	4,147	0.001	(Moulton et al. 2002b)
2002	9	3,618	0.002	(Moulton et al. 2003)
Average	11.75	3,997.5	0.003	

Figure 43 displays the bearded seals observed in 1999 (the year with the most observations). This figure provides a good representation of the locations bearded seals were observed over all 4 years (Richardson and Williams 2000). Annual reports (Richardson 2008) for years 2000 through 2002 include similar figures. Therefore, we have estimated a winter and spring density using the four years of Northstar development data of 0.003/km² bearded seals.

**Figure 43. Distribution of bearded seal sighting during Northstar aerial surveys, 4-13 June 1999 (Richardson and Williams 2000)**

To estimate the summer density of bearded seals, presence and sighting rates from monitoring programs within the areas surrounding Prudhoe Bay were used (Aerts et al. 2008; Harris et al. 2001; Hauser et al. 2008; Smultea et al. 2014). Of all the pinniped sightings during monitoring surveys, 63 percent were ringed seals, 17 percent were bearded seals, and 20 percent were spotted seals. Bearded seal density was calculated as a proportion of the ringed seal summer density of 0.27/km². Thus, the density of bearded seals during the open water season (summer and fall) was calculated as 17 percent of 0.27/km², resulting in an estimate of 0.05/km². There is no good information available on the presence or densities of bearded seals in the coastal areas of the Beaufort Sea during the fall, and therefore it is assumed that fall densities of bearded seals in Prudhoe Bay will be the same as the summer densities.

Feeding, Diving, Hauling out and Social Behavior

Bearded seals feed primarily on a variety of invertebrates (crabs, shrimp, clams, worms, and snails) some fish found on or near the seafloor (less than 200 m deep), and can also include school pelagic fish, when advantageous (Burns 1981; Cameron et al. 2010; Fedoseev 1984; Heptner et al. 1976; Nelson et al. 1984). They are believed to detect benthic prey by scanning the surface of the seafloor with their highly sensitive whiskers (Marshall et al. 2006). Bearded seals are considered opportunistic feeders whose diet varies with age, location, season, and changes in prey availability. Satellite tagging indicates that adults, subadults, and to some extent pups show some level of fidelity to feeding areas, often remaining in the same general area for weeks or months at a time (Cameron 2005, Cameron and Boveng 2009).

The diving behavior of adult bearded seals is closely related to their benthic foraging habits, and in the few studies conducted so far, dive depths have largely reflected local bathymetry (Gjertz et al. 2000; Krafft et al. 2000). Bearded seals typically dive to depths of less than 100 m (328 ft) for less than 10 minutes in duration, although dives of adults have been recorded up to 300 m (984 ft) and young-of-the-year have been recorded diving down to almost 500 m (1,640 ft); (Gjertz et al. 2000). Studies using depth recording devices have until recently focused on lactating mothers and their pups. Nursing mothers dive deeper on average than their pups, but by 6 weeks of age most pups had exceeded the maximum dive depth of lactating females (448 to 480 m [1,470 to 1,575 ft] versus 168 to 472 m [551 to 1,549 ft]; (Gjertz et al. 2000).

There are only a few quantitative studies concerning the activity patterns of bearded seals. Based on limited observations in the southern Kara Sea and Sea of Okhotsk it has been suggested that from late May to July bearded seals haul out more frequently on ice in the afternoon and early evening (Heptner et al. 1976). From July to April, three males (2 subadults and 1 young adult) tagged as part of a study in the Bering and Chukchi Seas rarely hauled out at all, even when occupying ice covered areas (Boveng and Cameron 2013). This is similar to both male and female young-of-year bearded seals tagged in Kotzebue Sound, Alaska (Frost et al. 2008). However, the diurnal pattern of haulout was different between the age classes in these two studies, with more of the younger animals hauling out in the late evening (Frost et al. 2008) versus adults favoring afternoon in June and evening from fall into spring (Boveng and Cameron 2013).

Studies using data recorders and telemetry on lactating females and their dependent pups showed

that, unlike other large phocid seals, bearded seals are highly aquatic during a nursing period of about three weeks (Lydersen and Kovacs 1999). At Svalbard Archipelago, nursing mothers spent more than 90 percent of their time in the water, split equally between near-surface activity and diving or foraging (Holsvik 1998; Krafft et al. 2000), while dependent pups spent about 50 percent of their time in the water, split between the surface (30 percent) and diving (20 percent; (Lydersen et al. 1994; Lydersen et al. 1996; Watanabe et al. 2009). Mothers traveled 48 km (30 mi) per day on average, and alternated time in the water with one to four short bouts on the ice to nurse their pups (Krafft et al. 2000).

In the spring, adult males are suspected to spend a majority of their time in the water vocalizing and defending territories, though a few observations suggest they are not entirely aquatic and may haul out near females with or without pups (Burns 1967; Fedoseev 1971; Finley and Renaud 1980).

Hearing and Vocalizations

Bearded seals vocalize underwater in association with territorial and mating behaviors. The predominant calls produced by males during breeding, termed trills, are described as frequency modulated vocalizations. Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km (19 mi), are up to 60 seconds in duration, and are usually associated with stereotyped dive displays (Cleator et al. 1989; Van Parijs 2003; Van Parijs and Clark 2006; Van Parijs et al. 2001; Van Parijs et al. 2003; Van Parijs et al. 2004).

Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, and make calls between 90 Hz and 16 kHz (Richardson et al. 1995). NMFS defines the function hearing range for phocids as 50 Hz to 86 kHz (NMFS 2018c).

4.3.3 Ringed seal

Status and Population Structure

Under the MMPA, NMFS recognizes one stock of Arctic ringed seals, the Alaska stock, in U.S. waters (and the action area). The Arctic ringed seal was listed as threatened under the ESA on December 28, 2012, primarily due to expected impacts on the population from declines in sea ice and snow cover on sea ice stemming from climate change within the foreseeable future (77 FR 76706).

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current abundance and trends for the Alaska stock can only be estimated by relying on these earlier studies. Frost et al. (2004) conducted aerial surveys within 40 km (25 mi) of shore in the Alaska Beaufort Sea during May and June from 1996 through 1999 and observed ringed seal densities ranging from 0.81 seals per square kilometer in 1996 to 1.17 seals per square kilometer in 1999. Moulton et al. (2002b) conducted similar, concurrent surveys in the Alaska Beaufort Sea between 1997 and 1999 but reported substantially lower ringed seal densities than Frost et al. (2004). The reason for this disparity was unclear (Frost et al. 2004). Bengtson et al.

(2005) conducted aerial surveys in the Alaska Chukchi Sea during May and June of 1999 and 2000. While the surveys were focused on the coastal zone within 37 km (23 mi) of shore, additional survey lines were flown up to 185 km (115 mi) offshore. Population estimates were derived from observed densities corrected for availability bias using a haul-out model from six tagged seals. Ringed seal abundance estimates for the entire survey area were 252,488 (standard error = 47,204) in 1999 and 208,857 (standard error = 25,502) in 2000. Using the most recent survey estimates from surveys by (Bengtson et al. 2005) and Frost et al. (2004) in the late 1990s and 2000, Kelly et al. (2010b) estimated the total population in the Alaska Chukchi and Beaufort seas to be at least 300,000 ringed seals. This estimate is likely an underestimate since the Beaufort Sea surveys were limited to within 40 km from shore.

Though a reliable population estimate for the entire Alaska stock is not available, research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted image-based aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these surveys are still being analyzed, but for the U.S. portion of the Bering Sea, Boveng et al. (2017) reported model-averaged abundance estimates of 186,000 and 119,000 ringed seals in 2012 and 2013, respectively. It was noted that these estimates should be viewed with caution because a single point estimate of availability (haul-out correction factor) was used and the estimates did not include ringed seals in the shorefast ice zone, which was surveyed using a different method. The authors suggested that the difference in seal density between years may reflect differences in the numbers of ringed seals using Russian versus U.S. waters between years, and they noted that if this was the case, the eventual development of comprehensive estimates of abundance for ringed seals in the Bering Sea that incorporate data in Russian waters may show less difference between years.

In September 2019, NMFS declared a UME for ice seals, recognized to have started on June 1, 2018. From the start date to April 15, 2020, the NMFS Standing Network had reports of 66 ringed seals (and 85 unidentified seals, some of which may have been ringed seals). This UME is currently ongoing and the cause, or causes, of these deaths is currently being investigated by NMFS.

Distribution

Arctic ringed seals have a circumpolar distribution and are found throughout the Arctic basin and in adjacent seasonally ice-covered seas. They remain with the ice most of the year and use it as a haul-out platform for resting, pupping, and nursing in late winter to early spring, and molting in late spring to early summer. During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas (Freitas et al. 2008; Harwood et al. 2015; Harwood and Stirling 1992; Kelly et al. 2010a). Harwood and Stirling (1992) reported that in late summer and early fall, aggregations of ringed seals in open-water in some parts of their study area in the southeastern Canadian Beaufort Sea where primary productivity was thought to be high. Harwood et al. (2015) also found that in the fall, several satellite-tagged ringed seals showed localized movements offshore east of Point Barrow in an area where bowhead whales are known to concentrate in the fall to feed on zooplankton. With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing

ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Crawford et al. 2012; Frost and Lowry 1984; Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010a).

Occurrence in the Action Area

Ringed seals are present along the marine transit route in the Bering, Chukchi, and Beaufort Seas, and near the pile-driving activities at West Dock in Prudhoe Bay. Ringed seals are resident in the Beaufort Sea year-round, and based on results of previous surveys in nearby Foggy Island Bay (approximately 30 km east of Prudhoe Bay) (Aerts et al. 2008; Funk et al. 2008; Savarese et al. 2010; Smultea et al. 2014), and monitoring from Northstar Island (approximately 18km northwest of Prudhoe Bay) (Aerts and Richardson 2009; Aerts and Richardson 2010), they are expected to be the most commonly occurring pinniped in the action area year-round.

Ringed seals are present in the nearshore Beaufort Sea waters and sea ice year-round, maintaining breathing holes and excavating subnivean lairs, primarily in the landfast ice during the ice-covered season. Ringed seals overwinter in the landfast ice in and around the Prudhoe Bay action area. There is some evidence indicating that ringed seal densities are low in water depths of less than 3 m, where landfast ice extending from the shoreline generally freezes to the sea bottom in very shallow waters (bottom-fast ice) during the course of the winter (Moulton et al. 2002a; Moulton et al. 2002b; Richardson and Williams 2003). Ringed seal movements during winter and spring are typically quite limited, especially where ice cover is extensive (Kelly et al. 2010a). During April to early June (the reproductive period), radio-tagged ringed seals inhabiting shorefast ice near Prudhoe Bay had home range sizes generally less than 1,336 ac (500 ha) in area (Kelly et al. 2005).

Limited data are available on ringed seal densities in the southern Beaufort Sea during the winter months; however, ringed seal winter ecology studies conducted in the 1980s (Frost and Burns 1989; Kelly et al. 1986) and surveys associated with the Northstar development (Williams et al. 2001) provide information on both seal ice-structure use (where ice structures include both breathing holes and subnivean lairs), and on the density of ice structures (Table 33).

Table 33. Summary of sea-ice structure density

Year	Ice-structure density/km ²	Source
1982	3.6	Frost and Burns 1989
1983	0.81	Kelly et al. 1983
Dec 1999	0.17	Williams et al. 2001
May 2000	1.2	Williams et al. 2001
Average structure density/km ²		1.45

Kelly et al. (1986) found that in the southern Beaufort Sea and Kotzebue Sound, radio-tagged seals used more than 1 and as many as 4 subnivean lairs. The distances between lairs was up to 4

km (10 mi), with numerous breathing holes in-between (Kelly et al. 1986). While Kelly et al. (1986) calculated the average number of lairs used per seal to be 2.85, they also suggested that this was likely to be an underestimate. To estimate winter ringed seal density within the project area, the average ice structure density of 1.45/km² (Table 33) was divided by the average number of ice structures used by an individual seal of 2.85 (SD=2.51; Kelly et al. 1986). This results in an estimated density of 0.51 ringed seals/km² during the winter months. This density is likely to be overestimated due to the suggestion by Kelly et al. (1986) that their estimate of the average number of lairs used by a seal was an underestimate.

For spring ringed seal densities, aerial surveys flown in 1997 through 2002 over Foggy Island Bay and west of Prudhoe Bay during late May and early June (Figure 44) (Frost et al. 2002; Moulton et al. 2002a; Richardson and Williams 2003), when the greatest percentage of seals have abandoned their lairs and are hauled out on the ice (Kelly et al. 2010a), provides the best available information on ringed seal densities.

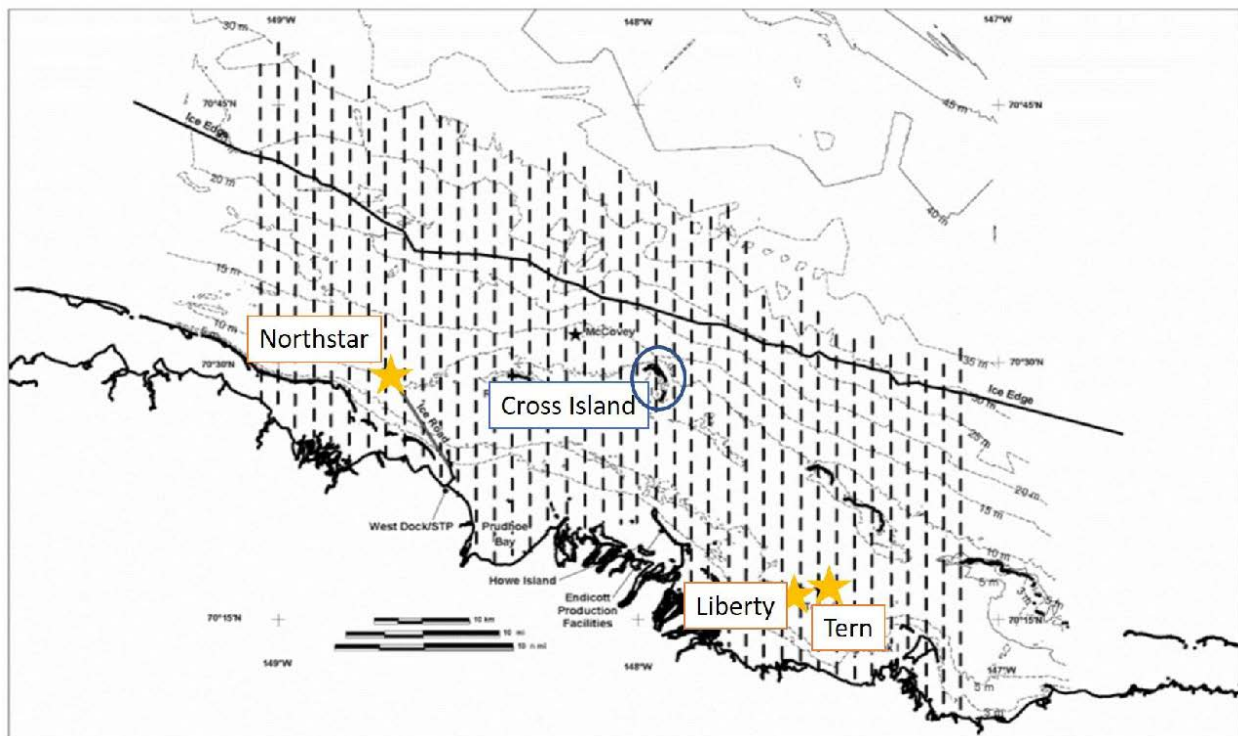


Figure 44. Ice seal aerial survey transects flown in May-June 2002. Similar surveys were flown in each year 1997-2001 (Richardson and Williams 2002).

Because densities were consistently very low where water depth was less than 3 m (and these areas are generally frozen solid during the ice-covered season) densities have been calculated where water depth was greater than 3 m deep (Moulton et al. 2002a; Moulton et al. 2002b; Richardson and Williams 2003). Based on the average density of surveys flown 1997 to 2002, the density of ringed seals during the spring is expected to be 0.548 ringed seals/km². A summary of available density data and the uncorrected densities available for 1997 to 2002 are provided in (Table 34).

Table 34. Estimated ringed seal densities during spring aerial surveys 1997–2002

Year	1997	1998	1999	2000	2001	2002	Average
Density (Number of seals/km ²)	0.43	0.39	0.63	0.47	0.54	0.83	0.548
Sources: Moulton et al. 2002b, Moulton et al. 2002c, Richardson and Williams 2003							

The highest observed density for the Prudhoe Bay area was used as the maximum. Because these density estimates were calculated from spring data and the numbers of seals is expected to be much lower during the open water season, the densities used for the proposed action were (conservatively) estimated to be 50 percent of the spring densities (Table 34), this resulted in an estimated density of 0.27 ringed seals/km². Ringed seals remain in the water through the fall and in to the winter. However, due to the lack of available data on fall densities within the Prudhoe Bay action area we have assumed the same density of ringed seals as in the summer; 0.27 ringed seals/km².

Feeding, Diving, Hauling out and Social Behavior

Ringed seal pups are born and nursed in the spring (March through May), normally in subnivean birth lairs, with the peak of pupping occurring in early April (Frost and Lowry 1981). Subnivean lairs provide thermal protection from cold temperatures, including wind chill effects, and some protection from predators (Smith 1976; Smith and Stirling 1975). These lairs are especially important for protecting pups. Arctic ringed seals appear to favor shore-fast ice for whelping habitat. Ringed seal whelping has also been observed on both nearshore and offshore drifting pack ice (e.g., Lentfer 1972). Seal mothers continue to forage throughout lactation, and move young pups between lairs within their network of lairs. The pups spend time learning diving skills, using multiple breathing holes, and nursing and resting in lairs (Lydersen and Hammill 1993; Smith and Lydersen 1991). After a 5 to 8 week lactation period, pups are weaned (Lydersen and Hammill 1993; Lydersen and Kovacs 1999).

Mating is thought to take place under the ice in the vicinity of birth lairs while mature females are still lactating (Kelly et al. 2010a). Ringed seals undergo an annual molt (shedding and regrowth of hair and skin) that occurs between mid-May to mid-July, during which time they spend many hours hauled out on the ice (Reeves 1998). The relatively long periods of time that ringed seals spend out of the water during the molt have been ascribed to the need to maintain elevated skin temperatures during new hair growth (Feltz and Fay 1966). Figure 45 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010a).

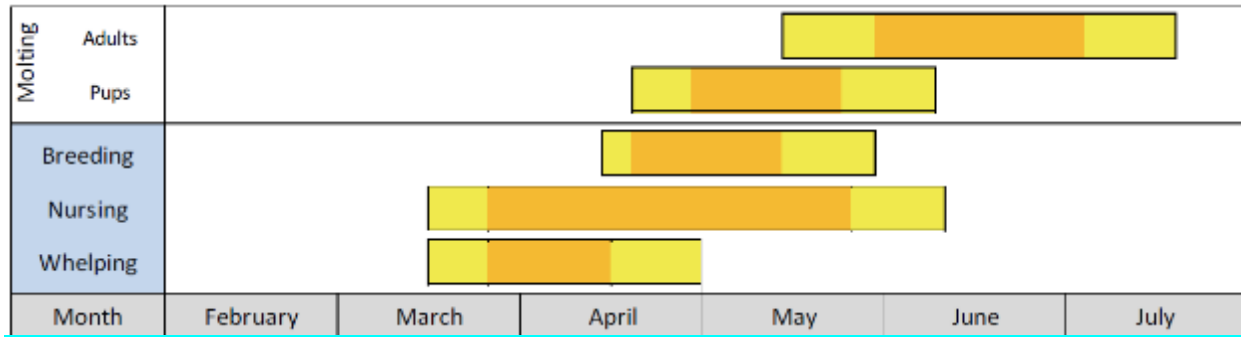


Figure 45. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicate the “peak” timing of each event (Kelly et al. 2010a).

Ringed seals tend to haul out of the water during the daytime and dive at night during the spring to early summer breeding and molting periods, while the inverse tended to be true during the late summer, fall, and winter (Carlens et al. 2006; Kelly et al. 2010a; Kelly et al. 2010b; Kelly and Quakenbush 1990; Lydersen 1991; Teilmann et al. 1999),.

Ringed seals feed year-round, but forage most intensively during the open-water period and early freeze-up, when they spend 90 percent or more of their time in the water (Kelly et al. 2010a). Many studies of the diet of Arctic ringed seal have been conducted and although there is considerable variation in the diet regionally, several patterns emerge. Most ringed seal prey is small, and preferred prey tends to be schooling species that form dense aggregations. Fish of the cod family tend to dominate the diet from late autumn through early spring in many areas (Kovacs 2007). Arctic cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals, especially during the ice-covered periods of the year (Holst et al. 2001; Labansen et al. 2007; Lowry et al. 1980; Smith 1987). Quakenbush et al. (2011) reported evidence that in general, the diet of Arctic ringed seals sampled from Alaska waters consisted of cod, amphipods, and shrimp. Fish are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by availability of various types of prey during particular seasons as well as preference, which in part is guided by energy content of various available prey (Reeves 1998; Wathne et al. 2000). Invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open-water season and often dominate the diet of young animals (Holst et al. 2001; Lowry et al. 1980).

Hearing, Vocalizations, and Other Sensory Capabilities

Ringed seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, and make calls between 90 Hz and 16 kHz (Richardson et al. 1995). NMFS defines the function hearing range for phocids as 50 Hz to 86 kHz (NMFS 2018c).

Elsner et al. (1989) indicated that ringed seals primarily use vision to locate breathing holes from under the ice, followed by their auditory and vibrissal senses for short-range pilotage. Hyvärinen (1989) suggested that ringed seals in Lake Saimaa may use a simple form of echolocation along with a highly developed vibrissal sense for orientation and feeding in dark, murky waters. The

vibrissae likely are important in detecting prey by sensing their turbulent wakes as demonstrated experimentally for harbor seals (Dehnhardt et al. 1998). Sound waves could be received by way of the blood sinuses and by tissue conduction through the vibrissae (Riedman 1990).

4.3.4 Western North Pacific DPS and Mexico DPS Humpback Whales

Status and Population Structure

Humpback whales are found in all oceans of the world with a broad geographical range from tropical to temperate waters in the Northern Hemisphere and from tropical to near-ice-edge waters in the Southern Hemisphere. In 1970, the humpback whale was listed as endangered worldwide under the ESCA of 1969 (35 FR 18319; December 2, 1970), primarily due to overharvest by commercial whalers. Congress replaced the ESCA with the ESA in 1973, and humpback whales continued to be listed as endangered, and were considered “depleted” under the MMPA.

Following the cessation of commercial whaling, humpback whale numbers increased. NMFS conducted a global status review (Bettridge et al. 2015), and after analysis and extensive public review, NMFS published a final rule on September 8, 2016 (81 FR 62260), recognizing 14 DPSs. Four of these were designated as endangered and one as threatened, with the remaining nine not warranting ESA listing status.

Based on an analysis of migration between winter mating/calving areas and summer feeding areas using photo-identification, Wade et al. (2016) concluded that whales feeding in Alaskan waters belong primarily to the Hawaii DPS (recovered), with small numbers from the Western North Pacific DPS (endangered) and Mexico DPS (threatened) individuals. Along the marine transit route for the proposed project Aleutian Islands, Bering and Chukchi Seas), we consider Hawaii DPS individuals to comprise 85.6 percent of the humpback whales present, Mexico DPS individuals to comprise 11.3 percent, and the Western North Pacific DPS individuals to comprise 4.4 percent (Table 35). In Cook Inlet, which is considered part of the Gulf of Alaska summer feeding area, we consider Hawaii DPS individuals to comprise 89 percent of the humpback whales present, Mexico DPS individuals to comprise 10.5 percent, and Western North Pacific DPS individuals to comprise 0.5 percent (Table 35).

The Hawaii DPS is not listed under the ESA, and is comprised of 11,398 animals (CV=0.04). The annual growth rate of the Hawaii DPS is estimated to be between 5.5 and 6.0 percent. The Mexico DPS is threatened, and is comprised of approximately 3,264 animals (CV=0.06) (Wade et al. 2016) with an unknown, but likely declining, population trend (81 FR 62260). Approximately 1,059 animals (CV=0.08) comprise the Western North Pacific DPS (Wade et al. 2016) and the population trend for the Western North Pacific DPS is unknown. Humpback whales in the Western North Pacific remain rare in some parts of their former range, such as the coastal waters of Korea, and have shown little sign of recovery in those locations.

Whales from these three DPSs overlap on feeding grounds off Alaska, and are visually indistinguishable unless individuals have been photo-identified on breeding grounds and again on feeding grounds. All waters off the coast of Alaska may contain ESA-listed humpbacks.

Table 35. Percent probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (on left) (Wade et al. 2016).

Summer Feeding Areas	North Pacific Distinct Population Segments (DPS)			
	Western North Pacific (endangered) ^a	Hawaii (not listed)	Mexico (threatened)	Central America (endangered) ¹
Kamchatka	100	0	0	0
Aleutian I/ Bering/ Chukchi Seas	4.4	86.5	11.3	0
Gulf of Alaska	0.5	89	10.5	0
Southeast Alaska / Northern BC	0	93.9	6.1	0
Southern BC / WA	0	52.9	41.9	14.7
OR/CA	0	0	89.6	19.7

^aFor the endangered DPSs, these percentages reflect the 95 percent confidence interval of the probability of occurrence in order to give the benefit of the doubt to the species and to reduce the chance of underestimating potential takes.

Distribution

Humpback whales undertake seasonal migrations from their tropical calving and breeding grounds in winter to their high-latitude feeding grounds in summer. Humpbacks may be seen at any time of year in Alaska, but most individuals winter in temperate or tropical waters near Mexico, Hawaii, and in the western Pacific near Japan. In the spring, the animals migrate back to Alaska, where food is abundant. They tend to concentrate in several areas, including Southeast Alaska, Prince William Sound, Kodiak, the mouth of Cook Inlet, and along the Aleutian Islands (Ferguson et al. 2015a; Ferguson et al. 2015b).

Humpback whales occur throughout the central and western Gulf of Alaska from Prince William Sound to the Shumagin Islands. Seasonal concentrations are found in coastal waters of Prince William Sound, Barren Islands, Kodiak Archipelago, Shumagin Islands and south of the Alaska Peninsula. Large numbers of humpbacks have also been reported in waters over the continental shelf, extending up to 100 nm offshore in the western Gulf of Alaska (Wade et al. 2016).

Occurrence in the Action Area

Marine Transit Route

Humpback whales are found throughout the Aleutians Islands and the eastern Bering Sea during the summer months (Zerbini et al. 2006) and have been found as far north as the northeastern Chukchi Sea (Clarke et al. 2014). Ferguson et al. (2015b) identified a humpback whale feeding BIA in the Aleutian Islands that includes both the north and south side of Unalaska (Figure 46), with the highest densities of humpbacks occurring from June through September. These

observations suggest that it is likely that humpback whales will overlap with the marine transit route from Dutch Harbor to Prudhoe Bay, particularly during the summer months.

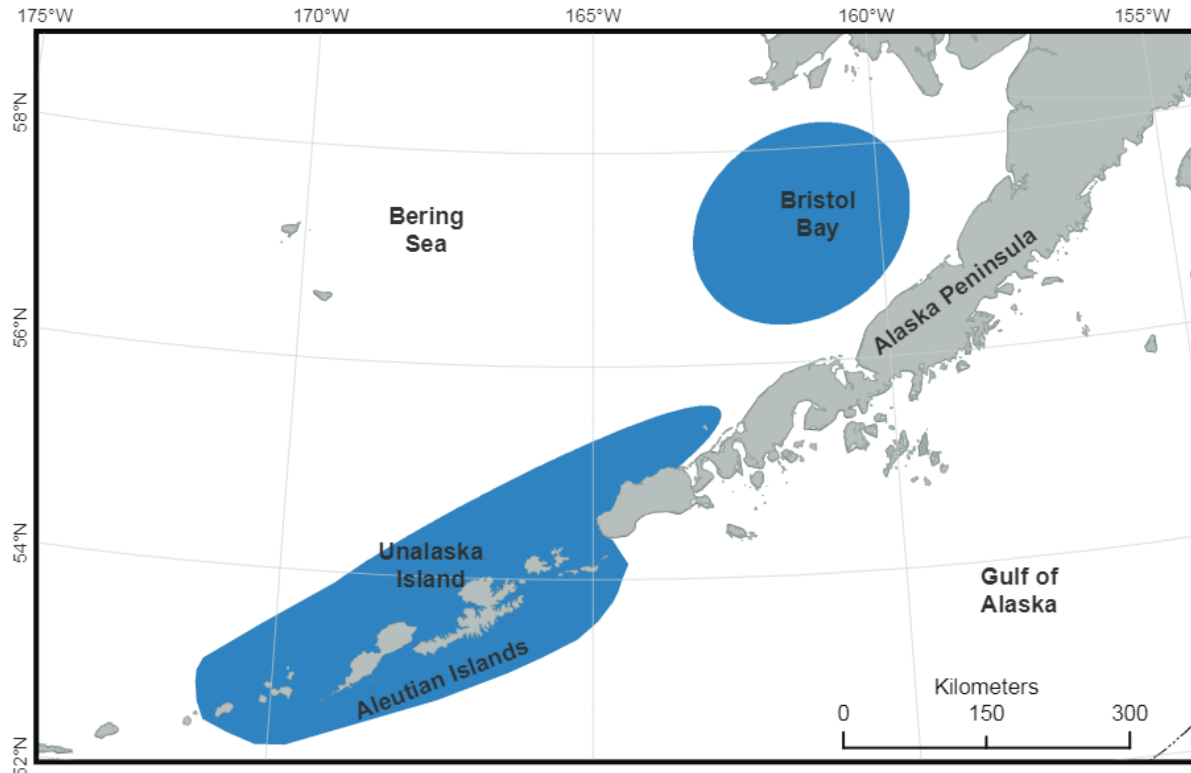


Figure 46. Humpback whale feeding BIAs identified around the Aleutian Islands and Bristol Bay. The highest whale densities were observed from June through September. These BIAs were based on a combination of satellite-tagging data, aerial- and vessel-based surveys, acoustic recordings, and photo-identification (Ferguson et al. 2015b, Figure 7.7).

Cook Inlet

Humpback whales have been observed throughout Cook Inlet, however they are primarily seen in lower and mid Cook Inlet. During the NMFS aerial beluga whale surveys from 1993–2016, there were 88 sightings of an estimated 192 individual humpback whales (Figure 47 and Table 35). A large number of these sightings occurred in the vicinity of Elizabeth Island, Iniskin and Kachemak Bays, and there were also a number of sightings north of Anchor Point (Rugh et al. 2000; Rugh et al. 2005; Sheldon et al. 2015a; Sheldon et al. 2017; Sheldon et al. 2013). Additionally, during the 2013 marine mammal monitoring program, marine mammal observers reported 29 sightings of 48 humpback whales (Owl Ridge 2014) at Cosmopolitan State well site #A-1 (on the eastern part of lower Cook Inlet, about six miles north of Ninilchik), and during the 2014 Apache seismic surveys in Cook Inlet (north and east of the action area), marine mammal observers reported six individuals (Lomac-MacNair 2014).

Recent studies and monitoring events have also documented humpback whales further north in Cook Inlet, indicating that humpbacks occasionally use the upper Inlet and are therefore potentially present and transiting through the action area. Marine mammal monitoring conducted

north of the Forelands in May and June of 2015 reported two humpback whales (Jacobs Engineering 2017). Shortly after these observations were made, a dead humpback was found in the same area, suggesting that this animal may have entered the area in a compromised state. PSOs observed two humpback whales near the mouth of Ship Creek, near Anchorage, some 60 miles (96 km) northeast of Nikiski, in early September 2017 during dock renovation work (ABR 2017). In 2017, a dead humpback whale was seen floating in Knik Arm, finally beaching at Kincaid Park; necropsy results were inconclusive. Recent monitoring by Hilcorp in upper Cook Inlet during the Cook Inlet Pipeline Extension project also included 3 humpback whale sightings near Ladd Landing, north of the Forelands (Sitkiewicz et al. 2018). Finally, in spring 2019, a young humpback whale stranded in Turnagain Arm (NMFS unpublished data).

For this action, the density of humpback whales in the action area was estimated as 0.00189 whales/km² using sightings from the NMFS aerial surveys conducted for beluga whales in June between 2000 and 2016 (Rugh et al. 2000, Rugh et al. 2005, Shelden et al. 2013, Shelden et al. 2015, Shelden et al. 2017). As mentioned above, of these whales, 0.5 percent are estimated to be from the Western North Pacific DPS, and 10.5 percent from the Mexico DPS (the remaining 89 percent being from the non-listed Hawaii DPS). Although there are a number of caveats to using these survey data for estimating density of species other than belugas, they represent the best available dataset for marine mammal sightings in Cook Inlet. These densities were also compared qualitatively to sightings in the monitoring reports mentioned above.

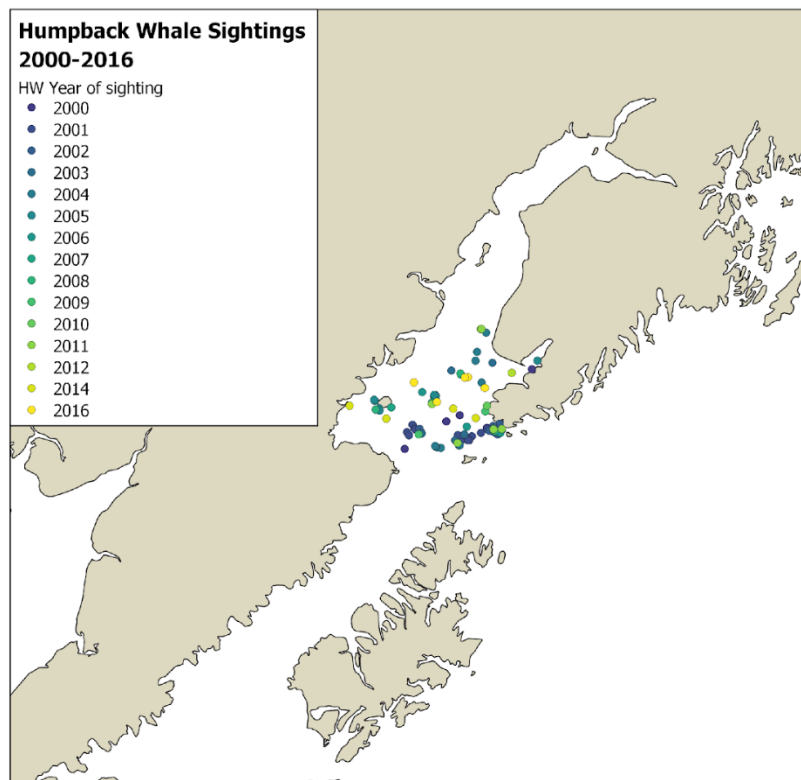


Figure 47. Humpback whale observations during aerial surveys for belugas in Cook Inlet, 2000-2016 (Rugh et al. 2000, Rugh et al. 2005, Shelden et al. 2013, Shelden et al. 2015, Shelden et al. 2017).

Table 36. Humpback whale sightings, including group size, during aerial surveys for belugas in Cook Inlet, 2000-2016

Year ^a	Month	No. Sightings	Group Size	Location (No. whales)
2018	June	0	0	-
2016	May	1	2	Mid-inlet, off Kachemak Bay, North of Port Graham (2)
2016	June	4	4	Mid-inlet, between Iniskin Peninsula and Kachemak Bay
2014	June	3	5	W. of Koyuktolik Island (4); Bruin Bay (1)
2014	June	1	6	S. of Augustine Island (6)
2012	May	1	1	Kachemak Bay (1)
2011	June	6	9	N. of Anchor Point, mid-inlet (3); N. of Barren Island (1); Elizabeth Island (3); E. of Augustine Island, mid-inlet
2010	June	2	4	N. of Koyuktolik Bay (4)
2009	June	1	3	N.W. of Barren Island (3)
2008	June	3	7	Elizabeth Island (5); W. of Kachemak Bay, mid-inlet (1); Augustine Island (1)
2007	June	2	3	Augustine Island (1); E. of Augustine Island, mid-inlet (2)
2006	June	7	14	S.E. Iniskin Peninsula, mid-inlet (1); W. of Kachemak Bay, mid-inlet (2); W. of Elizabeth Island (8); S. of Elizabeth Island (3)
2005	June	12	18	Kachemack Bay (1); Augustine Island (8); E. of Augustine Island, mid-inlet (6); S.E. Iniskin Peninsula, mid-inlet (3)
2004	June	10	15	W. of Kachemak Bay (3); N.W. of Barren Island (9); S.W. of Anchor Point, mid-inlet (1); N.W. of Anchor Point (2)
2003	June	5	22	Kachemak Bay (2); N.W. of Barren Island (12); N. Barren Island (3); S.W. of Anchor Point, mid-inlet (1); N.W. of Barren Island (4)
2002	June	8	20	Elizabeth Island (12); NW Barren Island (8)
2001	June	17	47	Kachemak Bay (12); N. of Barren Island (29), W. of Elizabeth Island (2), Elizabeth Island (4)
2000	June	5	11	Kachemak Bay (2); N. of Barren Island (7); E. of Shaw Island (1); W. of Elizabeth Island (1)
Total		88	191	

^aSource: 2018 (Shelden et al. 2019), 2016 (Shelden et al. 2017), 2014 (Shelden et al. 2015), 2000-2012 (Shelden et al. 2013)

Feeding and Prey Selection

Humpback whales in the North Pacific forage in the coastal and inland waters along California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Tomilin 1967). Of the four Biologically Important Areas (BIA) in the Gulf of Alaska described by Ferguson et al. (2015a) that are important feeding areas for humpback whales, the east side of Kodiak Island is the closest to the action area (Figure 48). Additionally, the feeding BIAs around the Aleutian Islands shown above (Figure 46, Ferguson et al. 2015b), also overlap with the marine transit portion of the action area.

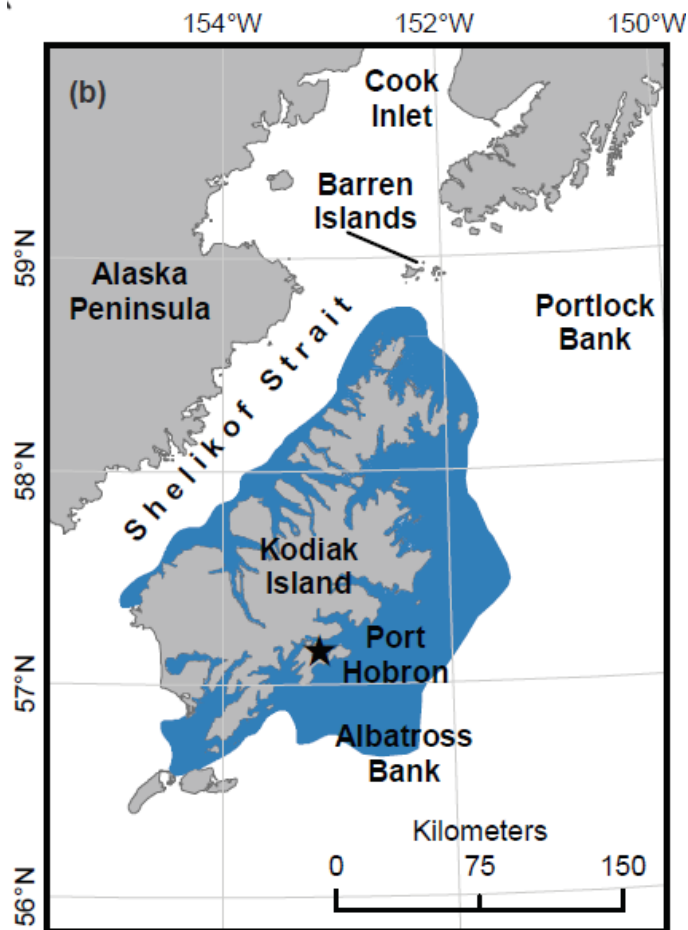


Figure 48. Seasonal humpback whale feeding BIA around Kodiak, near the mouth of Cook Inlet. During aerial surveys from 1999 to 2013, humpback whales were seen throughout the year in this area, with the greatest densities July-September (from Ferguson et al. 2015a, Figure 6.7(b)).

Their diverse diet is comprised of species including herring (*Clupea pallasii*), mackerel (*Scomber japonicus*), sand lance (*Ammodytes hexapterus*), juvenile walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*), Atka mackerel, Pacific cod (*Gadus microcephalus*), saffron cod (*Eleginus gracilis*), Arctic cod (*Boreogadus*

saida), juvenile salmon (*Oncorhynchus* spp.), and rockfish (*Sebastes* spp.) (Baker 1985; Geraci et al. 1989; Hain et al. 1982).

Humpback whales exhibit flexible feeding strategies, sometimes foraging alone and sometimes cooperatively (Clapham 1993). In many locations, feeding in the water column can vary with time of day, with whales bottom feeding at night and surface feeding near dawn (Friedlaender et al. 2009). In the Northern Hemisphere, feeding behavior is varied and frequently features novel capture methods involving the creation of bubble structures to trap and corral fish; bubble nets, clouds, and curtains can be observed when humpback whales are feeding on schooling fish (Hain et al. 1982).

Humpback whales are ‘gulp’ or ‘lunge’ feeders, capturing large mouthfuls of prey during feeding rather than continuously filtering food, as may be observed in some other large baleen whales (Goldbogen et al. 2008; Simon et al. 2012). When lunge feeding, whales advance on prey with their mouths wide open, then close their mouths around the prey and trap them by forcing engulfed water out past the baleen plates.

Hearing, Vocalizations, and Other Sensory Capabilities

Because of the lack of captive subjects and logistical challenges of bringing experimental subjects into the laboratory, no direct measurements of mysticete hearing are available. Consequently, hearing in mysticetes is estimated based on other means such as vocalizations (Wartzok and Ketten 1999), anatomy (Houser et al. 2001; Ketten 1997), behavioral responses to sound (Edds-Walton 1997), and nominal natural background noise conditions in their likely frequency ranges of hearing (Clark and Ellison 2004). The combined information from these and other sources strongly suggests that mysticetes are likely most sensitive to sound from an estimated tens of hertz to ~10 kHz (Southall et al. 2007). However, evidence suggests that humpbacks can hear sounds as low as 7 Hz up to 24 kHz, and possibly as high as 30 kHz (Au et al. 2006; Ketten 1997). These values fall within the NMFS (NMFS 2018c) generalized low-frequency cetacean hearing range of 7 to 35 kHz.

Because of their size, no audiogram has been produced for humpback whales. However, Helweg et al. (2000) and Houser et al. (2001) modeled a predicted audiogram based on the relative length of the basilar membrane (within the inner ear) of a humpback whale, integrated with known data on cats and humans. The result (Figure 49) shows sensitivity to frequencies from about 700 Hz to 10 kHz, with maximum relative sensitivity between 2 to 7 kHz. Because ambient noise levels are higher at low frequencies than at mid frequencies, the absolute sound levels that humpback whales can detect below 1 kHz are probably limited by increasing levels of natural ambient noise at decreasing frequencies (Clark and Ellison 2004).

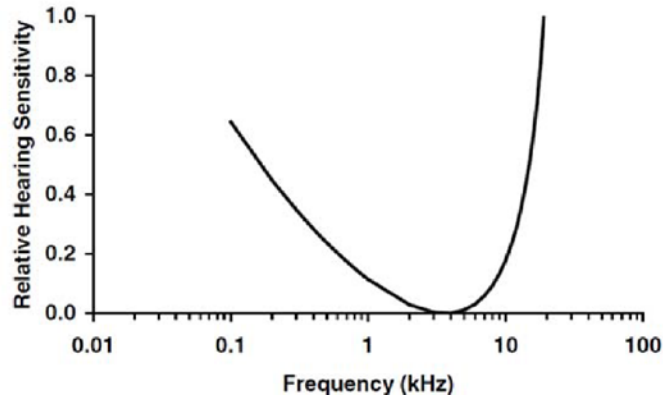


Figure 49. Predicted audiogram of humpback whale, derived by integrating the humpback frequency-position function with the sensitivity-position function derived from cat and human audiometric and anatomic data (Houser et al. 2001).

4.3.5 Cook Inlet DPS beluga whale

Status and Population Structure

Beluga whales inhabiting Cook Inlet are one of five distinct stocks found in Alaska (Muto et al. 2019). The best historical abundance estimate of the Cook Inlet beluga population was from a survey in 1979, which estimated a total population of 1,293 belugas (Calkins 1989). NMFS began conducting comprehensive, systematic aerial surveys of the Cook Inlet beluga population in 1993. These surveys documented a decline in abundance from 653 belugas in 1994 to 347 belugas in 1998 (Figure 50). In response to this nearly 50 percent decline, NMFS designated the Cook Inlet beluga population as depleted under the MMPA in 2000 (65 FR 34590; May 31, 2000). The lack of population growth since that time led NMFS to list the Cook Inlet beluga as endangered under the ESA on October 22, 2008 (73 FR 62919).

The best estimate of 2018 abundance for the Cook Inlet beluga whale population from the aerial survey data is 279 whales (95 percent probability interval 250 to 317) (Shelden and Wade 2019). A comparison of the population estimates over time is presented in Figure 50. Over the most recent 10-year time period (2008-2018), the estimated trend in abundance is approximately -2.3 (-4.1-0.6) percent/year (Figure 50) (Shelden and Wade 2019). This is a steeper decline than the previously estimated decline of -0.5 percent/year (Shelden et al. 2017). The methods presented in Shelden and Wade (2019) were developed by incorporating additional data and an improved methodology for analyzing the results of aerial population surveys. NMFS used a new group size estimation method (Boyd et al. 2019) and new criteria to determine whether certain data from aerial surveys could be used reliably. Shelden and Wade (2019) report abundance estimates dating back to 2004 that have been adjusted using the new methodology.

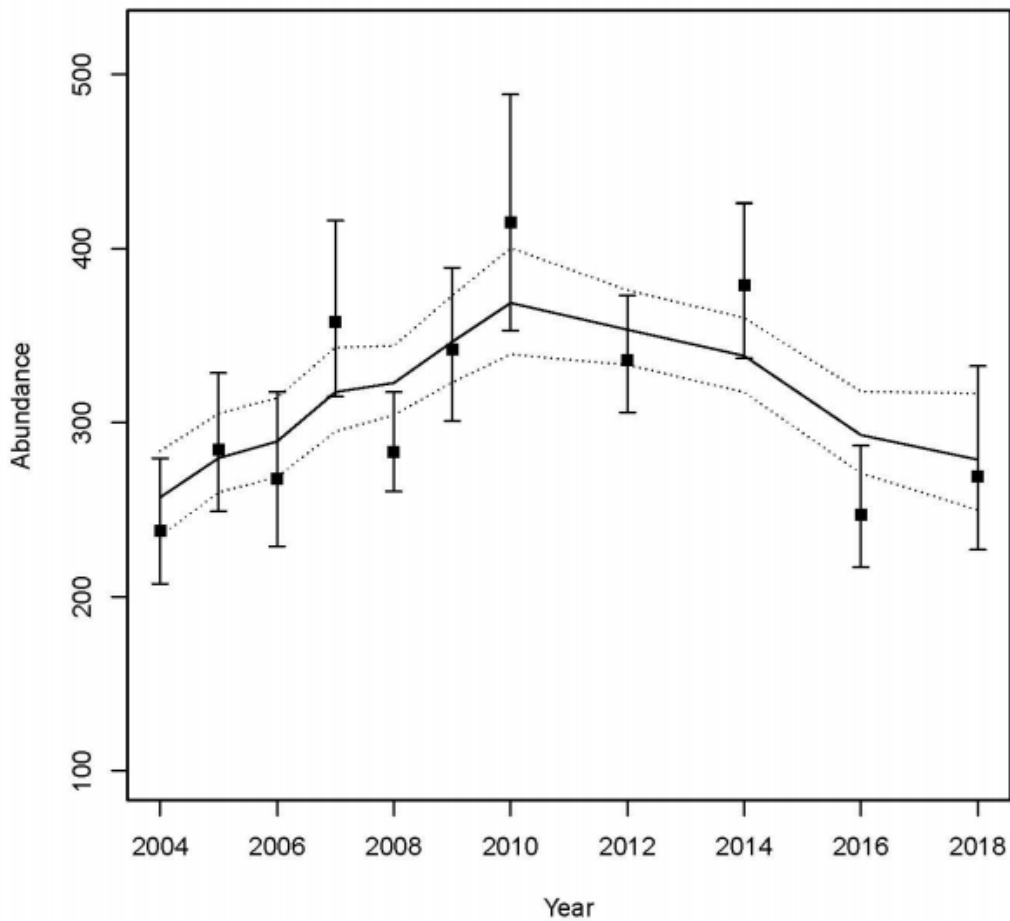


Figure 50. Cook Inlet beluga whale annual abundance estimates (squares) and 95 percent probability intervals (error bars) for the reanalyzed survey period 2004-2016 with results from 2018. The moving average is also plotted (solid line), with 95 percent probability intervals (dotted lines) (Shelden and Wade 2019).

The Cook Inlet Beluga Recovery Plan (NMFS 2016b) examined potential obstacles to the recovery of Cook Inlet belugas. Table 37 lists each threat identified in the recovery plan Table 37 lists each threat and summarizes the Recovery Team’s assessment of the major effect of the threat, its extent, frequency, trend, probability, magnitude, and rating of relative concern (among the threats identified) for Cook Inlet beluga recovery. Assessments were made based on the information and data gaps presented in the Background section of the recovery plan (NMFS 2016b).

Climate change, while considered a potential threat to beluga recovery, is not addressed as a separate threat in the recovery plan, but rather is discussed with respect to how it may affect each of the other listed threats. As stated above, the effects of greenhouse gas emissions are fundamentally changing global processes. The recovery plan does not attempt to identify the sources of such emissions or to assess the relative contribution of each potential source. Instead it focuses on the effects of a changing climate to belugas.

The Recovery Plan discusses the inherent risks associated with small populations, such as loss of genetic or behavioral diversity. The effects of threats on small populations may be greater than on large populations due to these inherent risks. Small populations may be more susceptible to disease, inbreeding, predator pits, or catastrophic events than large populations. The Recovery Plan addresses ten principal threats to the Cook Inlet beluga population and considers how they may be exacerbated by these types of inherent risks due to small population size.

Section 4(a)(1) of the ESA and the associated regulations (50 CFR part 424) set forth the considerations for the listing status of a species: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; or 5) other natural or human-made factors affecting its continued existence. Table 37 summarizes ten threats identified in the recovery plan for Cook Inlet beluga whales, associated with the relevant ESA section 4(a)(1) factors (identified as Factors A–E).

A detailed description of the Cook Inlet beluga whales' biology, habitat, and extinction risk factors may be found in the final listing rule for the species (73 FR 62919, October 22, 2008), the Conservation Plan (NMFS 2008a), and the Recovery Plan (NMFS 2016b). Additional information regarding Cook Inlet beluga whales can be found on the NMFS AKR web site at: <http://alaskafisheries.noaa.gov/protectedresources/whales/beluga.htm>.

Table 37. Summary of threats assessment for Cook Inlet beluga whales (NMFS 2016).

Threat Type	ESA § 4(a)(1) factor	Major effect	Extent	Frequency	Trend	Probability	Magnitude	Relative concern
Catastrophic events (e.g., natural disasters; spills; mass strandings)	A, D, E	Mortality, compromised health, reduced fitness, reduced carrying capacity	Localized	Intermittent & Seasonal	Stable	Medium to High	Variable Potentially High	High
Cumulative effects	C, D, E	Chronic stress; reduced resilience	Range wide	Continuous	Increasing	High	Unknown Potentially High	High
Noise	A, D, E	Compromised communication & echolocation, physiological damage, habitat degradation	Localized & Range wide	Continuous, Intermittent, & Seasonal	Increasing	High	Unknown Potentially High	High
Disease agents (e.g., pathogens; parasites; harmful algal blooms)	C	Compromised health, reduced reproduction	Range wide	Intermittent	Unknown	Medium to High	Variable	Medium
Habitat loss or degradation	A	Reduced carrying capacity, reduced reproduction	Localized & Range wide	Continuous & Seasonal	Increasing	High	Medium	Medium
Reduction in prey	A, D, E	Reduced fitness (reproduction and/or survival); reduced carrying capacity	Localized & Range wide	Continuous, Intermittent, & Seasonal	Unknown	Unknown	Unknown	Medium
Unauthorized take	A, E	Behavior modification, displacement, injury or mortality	Range wide, localized hotspots	Seasonal	Unknown	Medium	Variable	Medium
Pollution	A	Compromised health	Localized & Range wide	Continuous, Intermittent, & Seasonal	Increasing	High	Low	Low
Predation	C	Injury or mortality	Range wide	Intermittent	Stable	Medium	Low	Low
Subsistence hunting	B, D	Injury or mortality	Localized	Intermittent	Stable or Decreasing	Low	Low	Low

Distribution and Occurrence in the Action Area

Cook Inlet beluga whales are geographically and genetically isolated from other beluga whale stocks in Alaska (Muto et al. 2019). Their distribution heavily overlaps with the AK LNG project activities in upper Cook Inlet (Figure 8). Although they remain year-round in Cook Inlet, they demonstrate seasonal movements within the inlet. During the summer and fall, beluga whales generally occur in shallow coastal waters and are concentrated near the Susitna River mouth, Knik Arm, Turnagain Arm, and Chickaloon Bay (Castellote et al. 2016; Nemeth et al. 2007; Shelden et al. 2015b). During the winter, ice formation in the upper Inlet may restrict beluga's access to nearshore habitat (Ezer et al. 2013), and they are more dispersed 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.

Information on Cook Inlet beluga distribution, including aerial surveys and acoustic monitoring, indicates that the species' range in Cook Inlet has contracted markedly since the 1990s (Figure 51)(Shelden et al. 2015b). This distributional shift and range contraction coincided with the decline in abundance (Goetz et al. 2012; Moore et al. 2000; NMFS 2008a). Beginning in 1993, aerial surveys have been conducted annually or biennially in June and July by NMFS Marine Mammal Laboratory (Hobbs et al. 2012; NMFS 2008a). Historic aerial surveys for beluga whales also were completed in the late 1970s and early 1980s (Harrison and Hall 1978; Murray and Fay 1979). Results indicate that prior to the 1990s belugas used areas throughout the upper, mid, and lower Inlet during the spring, summer, and fall (Huntington 2000b; NMFS 2008a; Rugh et al. 2000; Rugh et al. 2010). While the surveys in the 1970s showed whales dispersing into the lower inlet by mid-summer, almost the entire population is now found only in northern Cook Inlet from late spring into the fall.

A recent analysis of year-round data from passive-acoustic monitors corroborates results of previous aerial surveys and telemetry data, indicating that Cook Inlet belugas tend to congregate around the mouths of the Susitna, Little Susitna, Beluga, Chickaloon, and Eagle Rivers during the summer months (Castellote et al. 2015). This distributional shift and contraction coincided with the decline in abundance (Goetz et al. 2012; Moore et al. 2000; NMFS 2008a).

The Susitna Delta (including the Little Susitna and Beluga Rivers) is a highly important area for Cook Inlet beluga whales, particularly in the summer-fall months. Groups of 200-300 individuals – almost the entire population – including adults, juveniles, and neonates, have been observed in recent years in the Susitna River Delta area (McGuire et al. 2014). Acoustic monitors at the Little Susitna River recorded a peak in daily hours positive for beluga detection from late May-early June, and a large peak from July-August (Figure 52)(Castellote et al. 2015). At the Beluga River (the site of the Mainline pipeline crossing on the west side of the Inlet), three peaks in beluga positive detections were recorded by the acoustic monitors: one from mid-February to early April, the strongest peak in June to mid-July, and the third peak in mid-November and December (Figure 53)(Castellote et al. 2015). These earlier peaks appear to coincide with eulachon runs in May and June (Vincent-Lang and Queral 1984), and salmon runs (particularly silver and Chinook salmon) from June-July (Brenner et al. 2019). NMFS refers to this preferred summer-fall habitat near the Susitna Delta as the Susitna Delta Exclusion Zone and seeks to minimize human activity in this area of extreme importance to Cook Inlet beluga whale survival and recovery.

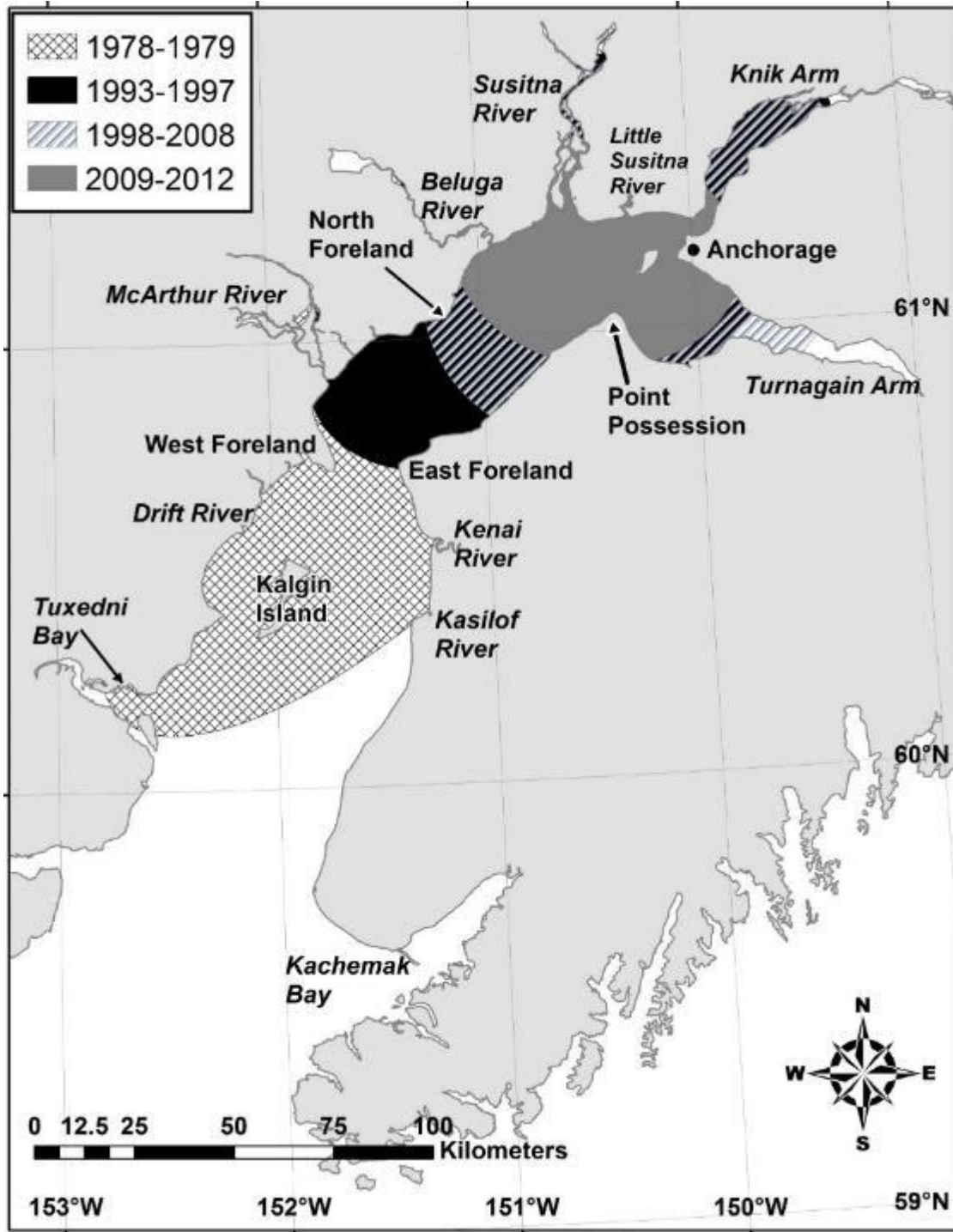


Figure 51. Summer range contraction over time as indicated by Alaska Department of Fish and Game and NMFS aerial surveys. (Adapted from Sheldon et al. 2015b).

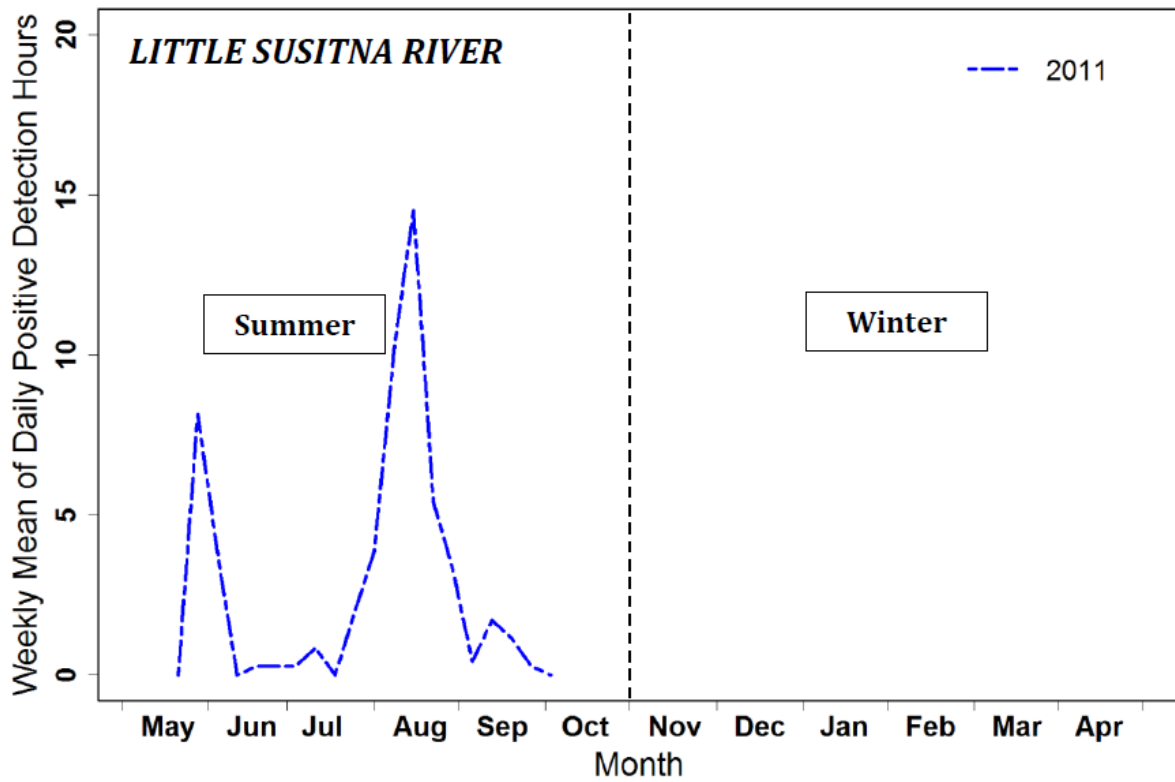


Figure 52. Weekly mean of daily beluga detection positive hours (DPH) by month at Little Susinta River, Cook Inlet, Alaska, 2011 (Castellote et al. 2015, Figure 3D).

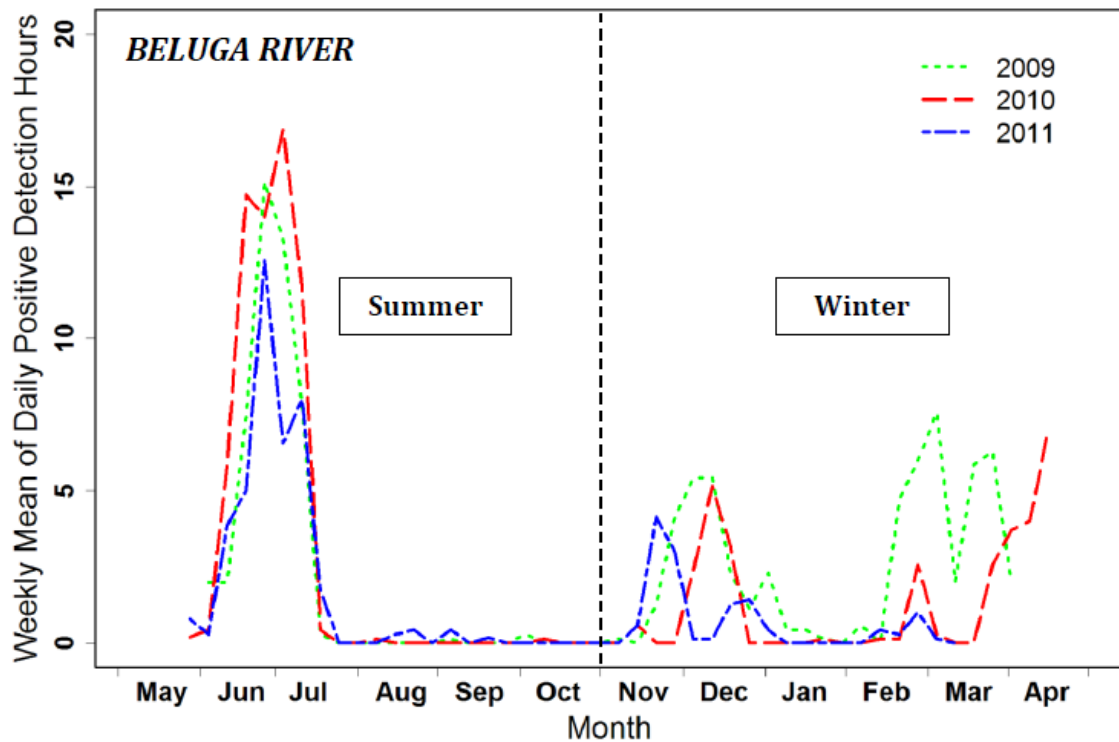


Figure 53. Weekly mean of daily beluga detection positive hours (DPH) by month at Beluga River, Cook Inlet, Alaska, 2009-2011 (Castellote et al. 2016, Figure 3E).

While belugas are concentrated primarily in the upper inlet during the summer and fall months, the area around the East Forelands between Nikiski, Kenai, and Kalgin Island appears to provide important wintering habitat for Cook Inlet beluga whales, and also during early spring and fall. Belugas were historically seen in and around the Kenai and Kasilof Rivers during June aerial surveys conducted by the Alaska Department of Fish and Game (ADFG) in the late 1970s and early 1980s and NMFS starting in 1993 (Shelden et al. 2015b), and throughout the summer by other researchers, local observations, etc., but in recent years have been seen more typically in the spring and fall (Ovitz 2019). While visual sightings indicate peaks in spring and fall, acoustic detections indicate that belugas may be present in the Kenai River throughout the winter (Figure 54; NMFS unpublished data (Castellote et al. 2016; NMFS unpublished data)). Combined, both the acoustic detections and visual sightings indicate that there appears to be a steep decline in beluga presence in the Kenai River area during the summer (June through August), despite the historic sightings of belugas throughout the summer in the area and the abundance of salmon, which is an important prey species, and of which the Kenai has the largest runs of any river in the Cook Inlet region.

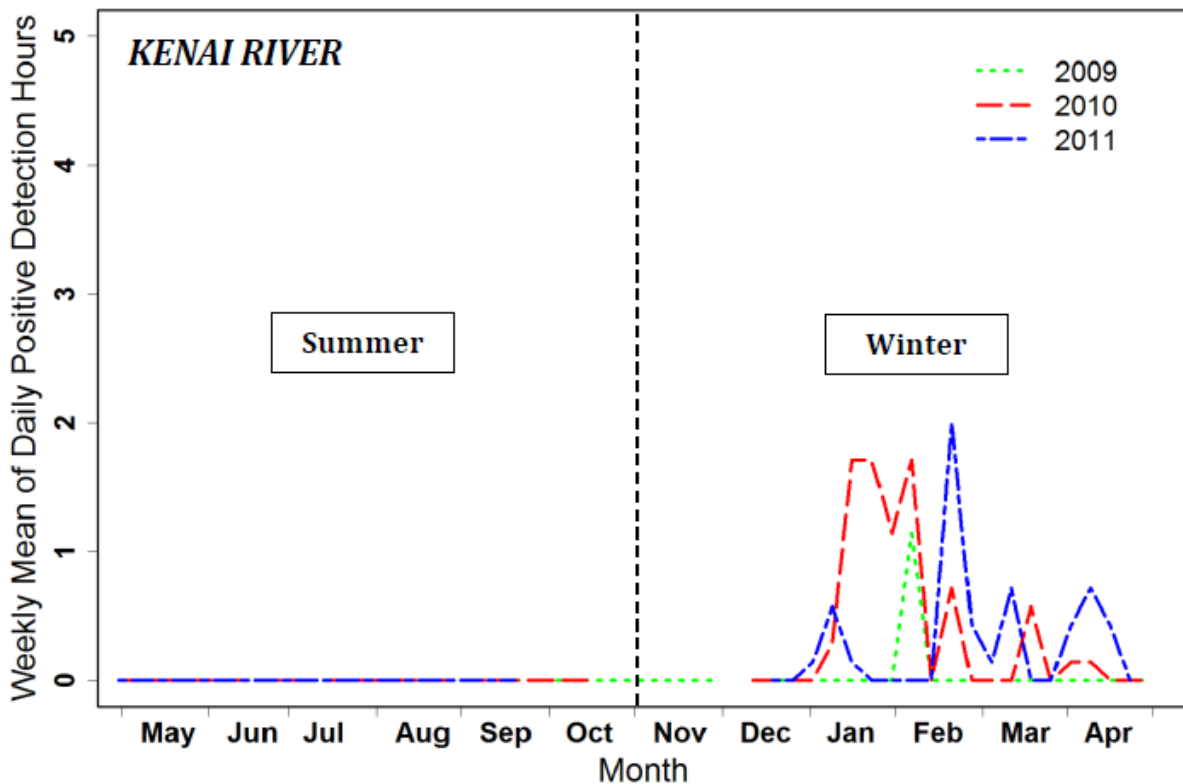


Figure 54. Acoustic detections of Cook Inlet beluga whales in the Kenai River from 2009 through 2011 compared to Chinook and Sockeye run timing. (Castellote et al. (2016), and fish run timing data at <http://www.adfg.alaska.gov/sf/FishCounts/index.cfm?adfg=main.home>, accessed August 3, 2017).

NMFS's records of opportunistic sightings contain thirteen records of beluga sightings in the Kasilof River between 1978 and 2015, with half of those sightings being since 2008 (Shelden et al. 2015b; NMFS unpublished data)). In 2018, surveys of local residents in the Kenai/Kasilof area were conducted by NMFS, where there were two reports of belugas in the Kasilof River in April; one of these reports was of a group of around 30 belugas (Ovitz 2019).

Belugas may be present in Tuxedni Bay (Figure 55) throughout the year, with peaks in acoustic detections in January and especially in March (Shelden et al. 2015b, Castellote et al. 2016). Belugas were seen in March 2018 and 2019 in Tuxedni Bay during NMFS winter distribution aerial surveys (NMFS unpublished data). While Tuxedni Bay is further from the project activities, belugas may need to travel through areas of project noise to reach Tuxedni Bay.

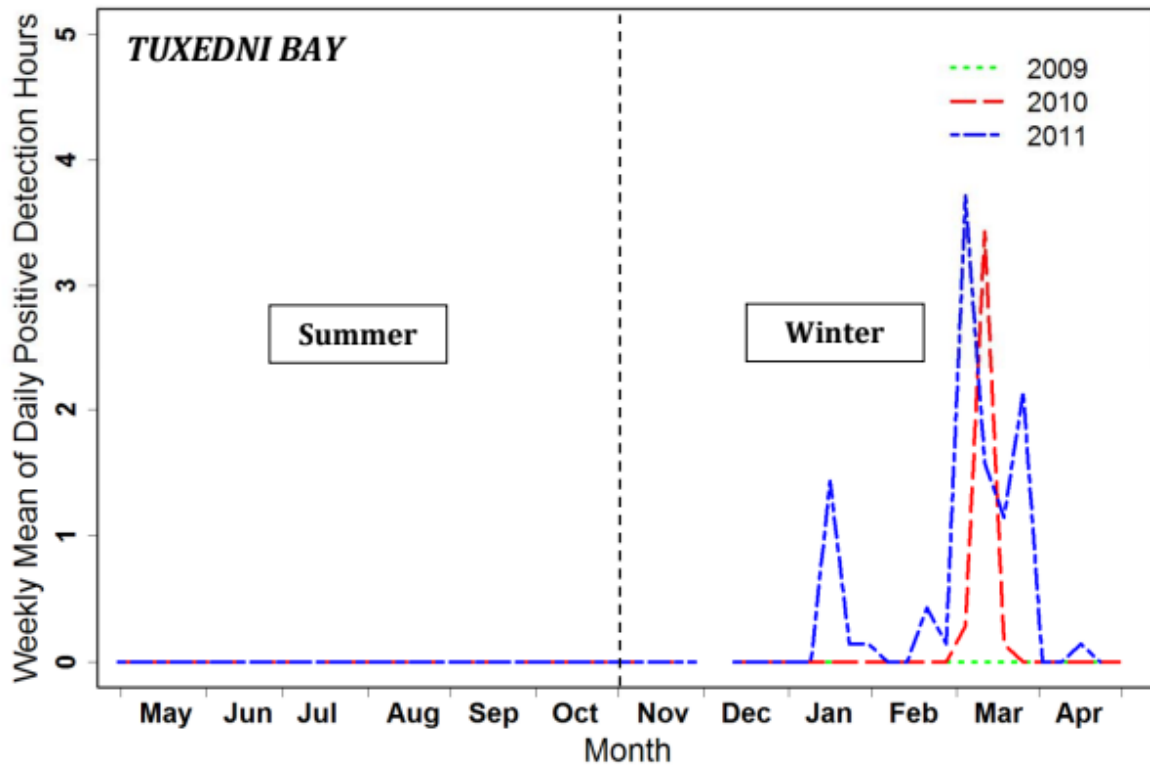


Figure 55. Detections of belugas in Tuxedni Bay using acoustic monitors from 2009-2011. (Castellote et al 2015, Figure 4G).

From December 2015 through January 2016, Tyonek Platform (located in upper Cook Inlet approximately 15 km offshore from the proposed mainline crossing site at Beluga Landing) personnel observed 200 to 300 Cook Inlet beluga whales, including calves, regularly. They appeared to be drifting by the platform on the afternoon tides, in the open water areas between ice sheets. One operator, working in Cook Inlet for 30 years, stated that he had never seen them in the winter before the 2015 to 2016 season (S. Callaway, pers. comm. 01/19/2016). Hilcorp reported 143 sightings of beluga whales from May-August while conducting pipeline work in upper Cook Inlet in an area near the proposed pipeline crossing (Sitkiewicz et al. 2018).

For this action, the densities of Cook Inlet beluga whales in multiple locations were based off of a habitat-based model developed by Goetz et al. (2012)(Figure 56). The Goetz et al. (2012) model was based on sightings, depth soundings, coastal substrate type, environmental sensitivity index, anthropogenic disturbance, and anadromous fish streams to predict densities throughout Cook Inlet. The result of this work is a beluga density map of Cook Inlet, which predicts spatially explicit density estimates for Cook Inlet belugas. Figure 56 shows the Goetz et al. (2012) density estimates with the project area. Using data from the Geographic Information System (GIS) files provided by NMFS and the different project locations, the resulting estimated density is shown in Table 38.

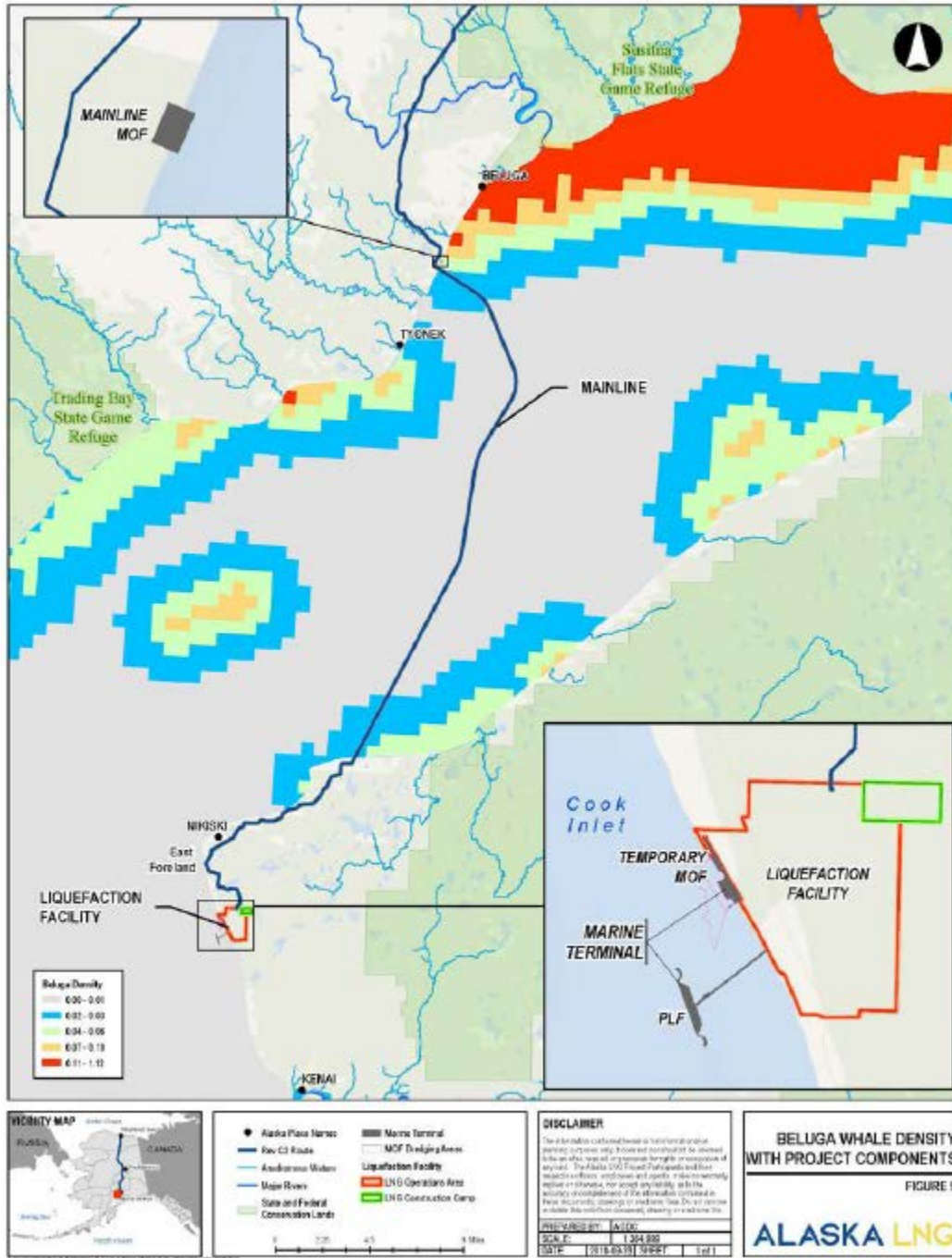


Figure 56. Beluga whale density modeled by Goetz et al. (2012) and the Alaska LNG project components.

Table 38. Average beluga whale density during late June within predicted Level A and B areas of ensonification

Project Component	Average Density within Level A Contour (animals/km²)	Average Density within Level B Contour (animals/km²)
PLF 48-in pipe piles, impact	0.00004	0.00005
PLF 60-in pipe piles, impact	0.00005	0.00005
Temporary MOF 24-in pipe piles, impact	-	0.00005
Temporary MOF 48-in pipe piles, impact	-	0.00005
Temporary MOF all pipe sizes, vibratory	-	0.00006
Temporary MOF sheet piles, vibratory	-	0.00005
Mainline MOF sheet piles, impact	0.04150	0.04146
Mainline MOF sheet piles, vibratory	-	0.03245
Anchor Handling Location - All	-	0.00551

Behavior and Group Size

Beluga whales are extremely social and often interact in close, dense groups. Most calving in Cook Inlet is assumed to occur from mid-May to mid-July (Calkins 1989; NMFS unpublished data). The only known observed occurrence of calving occurred on July 20, 2015 in the Susitna Delta area (T. McGuire, pers. comm. March 27, 2017). Young beluga whales are nursed for two years and may continue to associate with their mothers for a considerable time thereafter (Colbeck et al. 2013).

McGuire and Stephens (2017) observed increasing maximum group size of Cook Inlet beluga whales in recent years, and as mentioned above, groups of 200 or more individuals were first seen in 2012 and the maximum group size of 313 whales – almost the entire population – was seen in 2015 in the Susitna River Delta area. The first neonates encountered by the photo identification (ID) team during each field season from 2005 through 2015 were always seen in the Susitna River Delta in July. The photo ID team’s documentation of the dates of the first neonate of each year indicate that calving begins in mid-late July/early August, generally coinciding with the observed timing of annual maximum group size. A documented observation of a beluga whale birth occurred on July 20, 2015, in the Susitna River Delta, which corroborates the importance of the Susitna River Delta as a Cook Inlet beluga whale calving ground. Probable mating behavior of belugas was observed in April and May of 2014, in Trading Bay (Lomac-MacNair et al. 2016).

Feeding and Prey Selection

Cook Inlet beluga whales have diverse diets (Nelson et al. 2018; Quakenbush et al. 2015), foraging on fish and benthos, often at river mouths. Belugas seasonally shift their distribution within Cook Inlet in relation to the timing of fish runs and seasonal changes in ice and currents (NMFS 2016b). Generally, belugas spend the ice-free months in the upper Inlet, often concentrated in discrete areas such as the Susitna River Delta (McGuire and Stephens 2017), then expand their distribution south and into more offshore waters in winter (Hobbs et al. 2005). In early spring, some belugas travel up to Twenty Mile River and Placer Creek in Turnagain Arm, suggesting the importance of eulachon as a spring food source for belugas. Funk et al. (2005) confirmed early spring (March to May) and fall (August to October) use of Knik Arm.

In August-October, the increase in sightings and acoustic detections (Castellote et al. 2016) of belugas in Knik Arm coincides with the coho salmon run (NMFS 2016b). Later in the fall, many belugas disperse south, though few whales are observed in the lower inlet. In winter, belugas occur in the upper inlet as well as the lower inlet (Shelden et al. 2015b). Acoustic results suggest that some belugas may enter Knik Arm in December, January, March, and April, but their numbers do not markedly increase until May (Castellote et al. 2016).

A recent study using stable isotopes on historical and recent beluga bone samples suggests that the diets of Cook Inlet belugas have shifted over time (i.e., since the 1980s) to a diet influenced more by freshwater prey (Nelson et al. 2018). The cause of this dietary shift is unknown, but appears to have begun before the documented population decline.

Hearing, Vocalizations, and Other Sensory Capabilities

Like other odontocetes, or toothed cetaceans, beluga whales produce sounds for two overlapping functions: communication and echolocation. For their social interactions, belugas emit communication calls with an average frequency range of about 0.2 to 7.0 kHz (well within the human hearing range)(Garland et al. 2015), and the variety of audible whistles, squeals, clucks, mews, chirps, trills, and bell-like tones they produce have led to their nickname of “canaries of the sea” (Castellote et al. 2014). Belugas and other odontocetes make sounds across some of the widest frequency bands that have been measured in any animal group.

At the higher frequency end of their hearing range, belugas use echolocation signals (biosonar) with peak frequencies at 40-120 kHz (Au 2000) to navigate and hunt in dark or turbid waters, where vision is limited. Beluga whales are one of five non-human mammal species for which there is convincing evidence of frequency modulated vocal learning (Eaton 1979; Payne and Payne 1985; Stoeger et al. 2012; Tyack 1999).

Even among odontocetes, beluga whales are known to be among the most adept users of sound. It is possible that the beluga whale’s unfused vertebrae, and thus the highly movable head, have allowed adaptations for their sophisticated directional hearing. Multiple studies have examined hearing sensitivity of belugas in captivity (Awbrey et al. 1988; Finneran et al. 2005; Finneran et al. 2002a; Finneran et al. 2002b; Johnson et al. 1989; Klishin et al. 2000; Mooney et al. 2008; Ridgway et al. 2001), however the results are difficult to compare across studies due to varying research designs, complicating factors such as ototoxic antibiotics (e.g., Finneran et al. 2005),

and small sample sizes. In the first report of hearing ranges of belugas in the wild, (Castellote et al. 2014) reported a wide range of sensitive hearing from 20-110 kHz, with minimum detection levels around 50 dB. In general, these results were similar to the ranges reported in the captive studies, however the levels and frequency range indicate that these belugas have sensitive hearing when compared to previous beluga studies and other odontocetes (Houser et al. 2008; Houser and Finneran 2006)(Figure 57).

Most of these studies measured beluga hearing in very quiet conditions. However, in Cook Inlet, tidal currents regularly produce ambient sound levels well above 100 dB (Lammers et al. 2013). Belugas' signal intensity can change with location and background noise levels (Au et al. 1985).

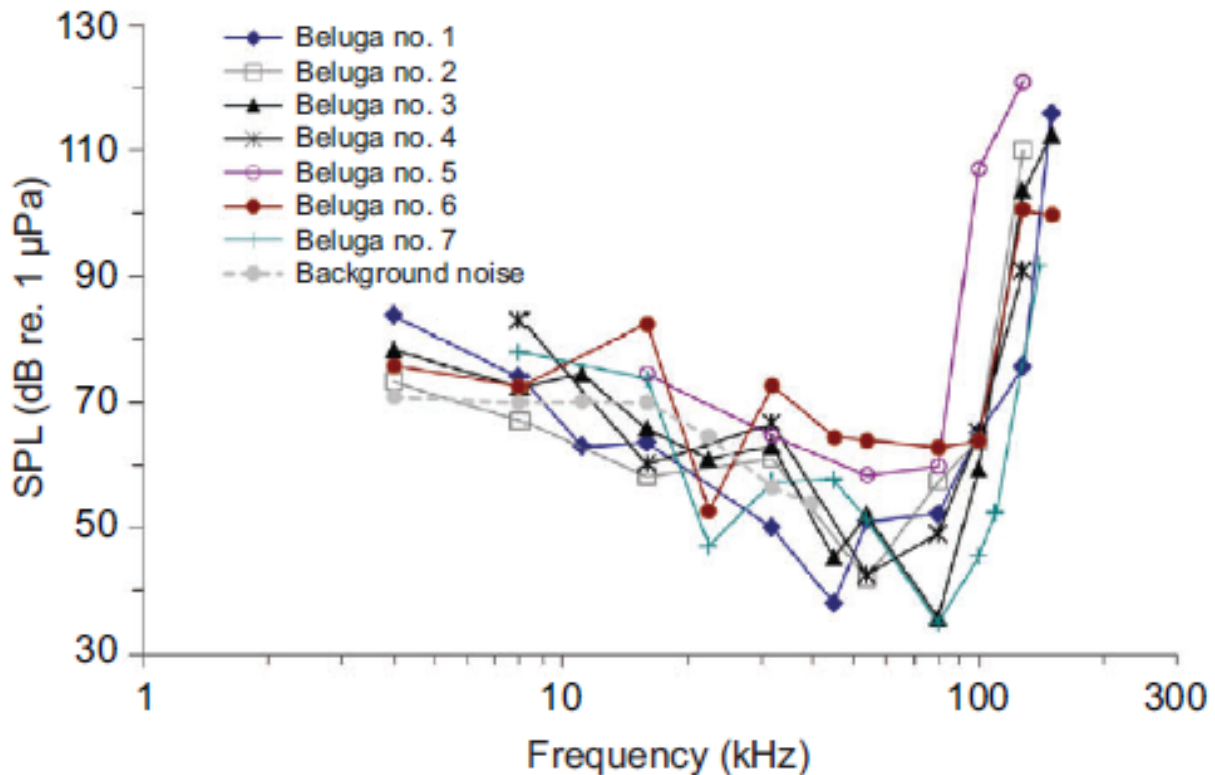


Figure 57. Audiograms of seven wild beluga whales. (Castellote et al. 2014).

4.3.6 Fin whale

Status and Population Structure

The fin whale (*Balaenoptera physalus*) was listed as an endangered species under the ESCA on December 2, 1970 (35 FR 18319), and continued to be listed as endangered following passage of the ESA (39 FR 41367). Critical habitat has not been designated for fin whales. A recovery plan for the fin whale was published on July 30, 2010 (NMFS 2010b). Fin whales have two recognized subspecies: *B. p. physalus* occurs in the North Atlantic Ocean (Gambell 1985), while *B. p. quoyi* occurs in the Southern Ocean (Fischer 1829). Most experts consider the North Pacific fin whales a separate unnamed subspecies.

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale population prior to whaling, and (2) estimates of the current size of the different fin whale populations vary widely. Prior to exploitation by commercial whalers, fin whales are thought to have numbered greater than 464,000 worldwide, and are now thought to number approximately 119,000 worldwide (Braham 1991). As used in this opinion, “populations” are isolated demographically, meaning they are driven more by internal dynamics like birth and death processes than by the geographic redistribution of individuals through immigration or emigration.

NMFS recognizes three management units or “stocks” of fin whales in U.S. Pacific waters: (1) Alaska (Northeast Pacific), (2) California/Washington/Oregon, and (3) Hawaii (Muto et al. 2019). However, Mizroch et al. (2009) suggest that this structure should be reviewed and updated, if appropriate, to reflect current data that suggests there may be at least 6 populations of fin whales in this region.

Ohsumi and Wada (1974) estimated that the Northeast Pacific fin whale population ranged from 42,000-45,000 before whaling began. Dedicated line transect cruises were conducted in coastal waters of western Alaska and the eastern and central Aleutian Islands in July and August 2001-2003 (Zerbini et al. 2006), which resulted in an estimate of 1,652 (95 percent CI: 1,142-2,389) fin whales in the area.

In 2013 and 2015, dedicated line-transect surveys of the offshore waters of the Gulf of Alaska provided fin whale abundance estimates of 3,168 fin whales (CV=0.26) in 2013 and 916 (CV=0.39) in 2015. The marked differences in these estimates can be partially explained by differences in sampling coverage across the two cruises (Rone et al. 2017).

The estimates of fin whale abundance in the eastern Bering Sea and in the Gulf of Alaska are considered to be biased low due because the geographic coverage of surveys was limited relative to the range of the stock. Additionally, these surveys have not been corrected for animals missed on the trackline, animals submerged when the ship passed, and responsive movement. However, data for these corrections is not currently available, and previous studies have shown that these sources of bias are small for this species (Barlow 1995).

Zerbini et al. (2006) estimated an annual rate of increase of 4.8 percent (95 percent CI: 4.1-5.4 percent) for the period of 1987-2003, however this trend should be used with caution due to the uncertainties in the initial population estimate (1987) and the population structure of fin whales in the area. Additionally, the study represented only a small fraction of the range of the Northeast Pacific stock and it may not be appropriate to extrapolate this to a broader range.

A more recent trend in abundance estimated by Friday et al. (2013) of 14 percent (95 percent CI: 1.0-26.5 percent) annual rate of increase in abundance of fin whales from 2002 to 2010 is higher than most plausible estimates for large whale populations (Zerbini et al. 2010). This high rate of increase may be explained, at least in part, by changes in distribution (possibly driven by changes in prey distribution) rather than population growth (Muto et al. 2019).

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean (where they have recently begun to appear). In the North Pacific, fin whales are found in summer foraging areas in the Gulf of Alaska, Bering Sea/Aleutian Islands, and as far north as the northern Chukchi Sea (Muto et al. 2019).

Information on seasonal fin whale distribution has been gleaned from the reception of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998; Moore et al. 2006; Širović et al. 2013; Soule and Wilcock 2013; Stafford et al. 2007; Watkins et al. 2000) These studies documented high levels of fin whale call rates along the U.S. Pacific coast beginning in August/September and lasting through February, suggesting that these may be important feeding areas during the winter. Fin whales have been acoustically detected in the Gulf of Alaska year-round, with highest call occurrence rates from August through December and lowest call occurrence rates from February through July (Moore et al. 2006, Stafford et al. 2007).

A migratory species, fin whales generally spend the spring and early summer feeding in cold, high latitude waters as far north as the Chukchi Sea, with regular feeding grounds in the Gulf of Alaska, Prince William Sound, along the Aleutian Islands, and around Kodiak Island, primarily on the western side. Ferguson et al. (2015b) identified feeding habitat around Kodiak Island, south of the mouth of Cook Inlet, as a BIA for fin whales, based on boat and aerial-survey data that indicate the highest densities of fin whales occur between June and August (Figure 58). Additionally, Ferguson et al. (2015a) identified a feeding BIA in the Bering Sea where the highest densities of fin whales occur from June to September, based on a combination of ship-based surveys, and acoustic and historical whaling data (Figure 59). In the fall, fin whales tend to return to low latitudes for the winter breeding season, though some may remain in residence in their high latitude ranges if food resources remain plentiful. In the eastern Pacific, fin whales typically spend the winter off the central California coast and into the Gulf of Alaska. (Panigada et al. 2008) found water depth to be the most significant variable in describing fin whale distribution, with more than 90 percent of sightings occurring in waters deeper than 2,000 m.

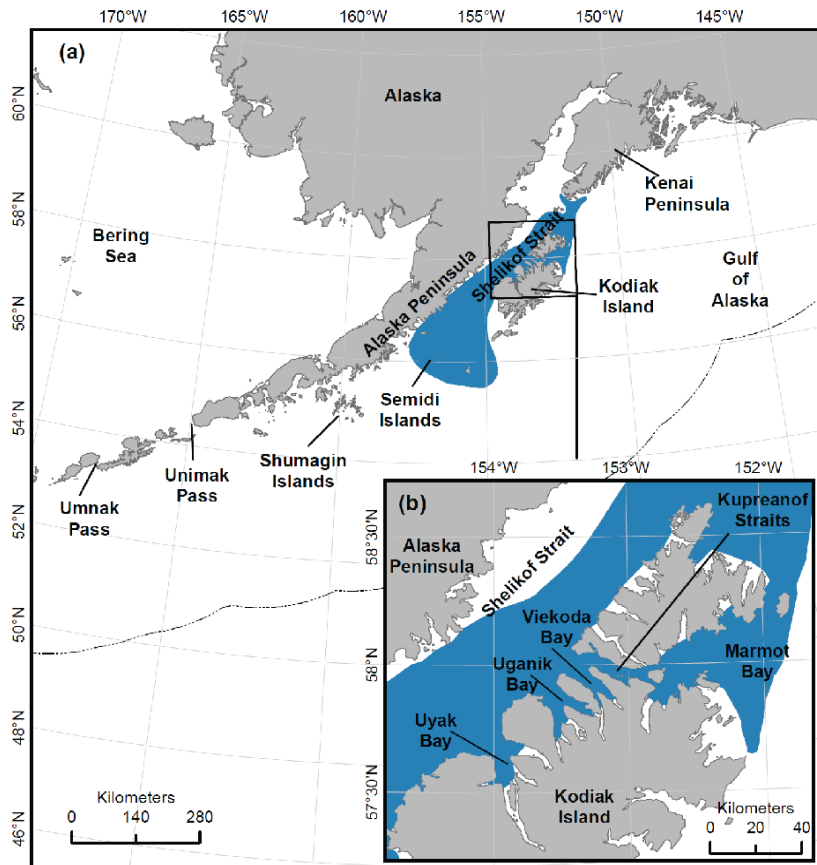


Figure 58. (a) Fin whale Biologically Important Area (BIA) for feeding around Kodiak Island in the Gulf of Alaska. The dashed line indicates the U.S. Exclusive Economic Zone (EEZ). (b) Close-up of the BIA around the northern end of Kodiak Island. Based on boat- and aerial-survey data, the greatest densities of fin whales are found in this BIA from June through August (Ferguson et al. 2015b, Figure 6.1).

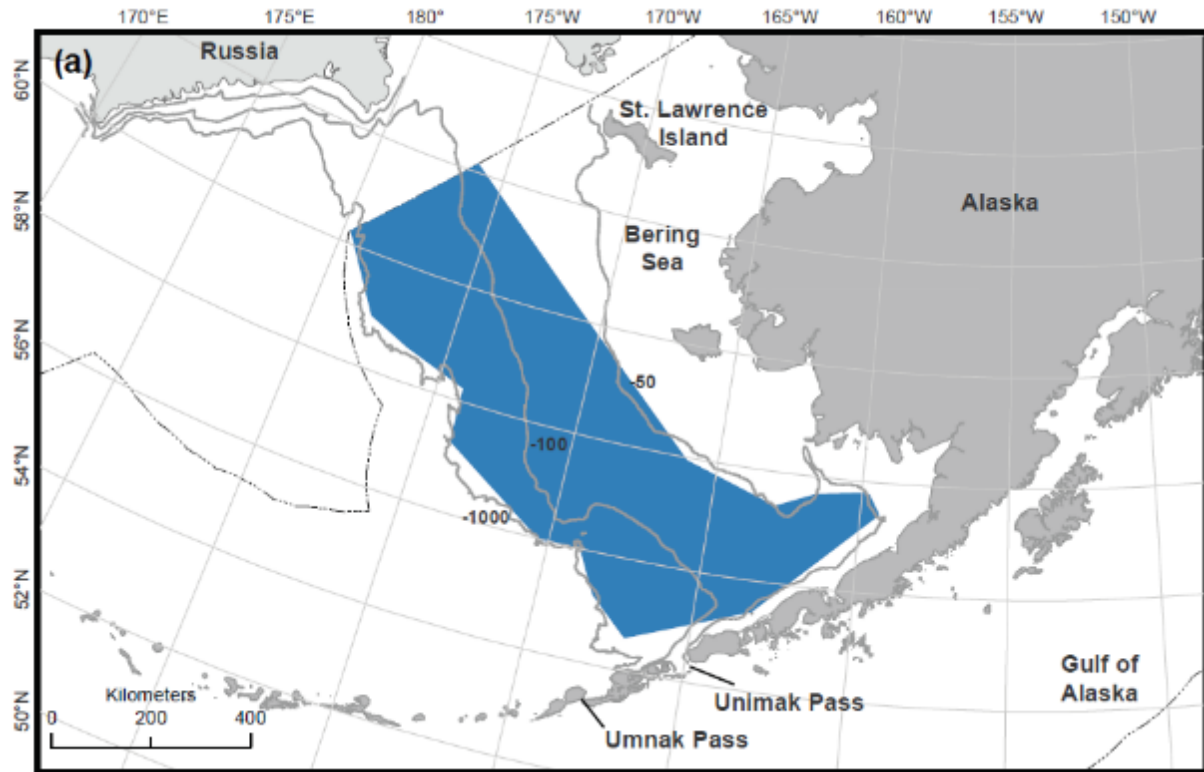


Figure 59. Fin whale Biologically Important Area (BIA) for feeding in the Bering Sea. Highest densities are from June through September, substantiated through ship-based surveys, acoustic recordings, and whaling data. Also shown are 50-, 100-, and 1,000-m isobaths, which were used to delineate the hydrographic domains in the region (Ferguson et al. 2015a, Figure 7.3).

There is considerable variation in grouping frequency by region. In general, fin whales, like all baleen whales, are not very socially organized and most fin whales are observed as singles. Fin whales are also sometimes seen in social groups that can number 2 to 7 individuals. However, up to 50, and occasionally as many as 300, can travel together on migrations (NMFS 2010d). Fin whales in the Cook Inlet have only been observed as individuals or in small groups.

Occurrence in the Action Area

Marine Transit Route

Fin whales have been visually observed in the Bering Sea during winter months (Mizroch et al. 2009) and have been detected acoustically in the southeastern Bering Sea throughout the year (NMML, unpublished data, May 2007–May 2011; Clapham et al. 2012). Additionally, in the northeastern Chukchi Sea, visual sightings and acoustic detections have been increasing, which suggests the stock may be re-occupying habitat used prior to large-scale commercial whaling (Muto et al. 2019). Most of these areas are feeding habitat for fin whales, suggesting that fin whales will overlap with the proposed action’s Marine Transit Route

Cook Inlet

An opportunistic survey conducted on the shelf of the Gulf of Alaska found fin whales concentrated west of Kodiak Island in Shelikof Strait, and in the southern Cook Inlet region. Smaller numbers were also observed over the shelf east of Kodiak to Prince William Sound (Alaska Fisheries Science Center 2003).

Fin whales are rarely observed in Cook Inlet and most sightings occur near the entrance of the inlet. During the NMFS aerial beluga whale surveys in Cook Inlet from 2000 through 2016, 10 sightings of approximately 26 individual fin whales in lower Cook Inlet were observed (Figure 60)(Shelden et al. 2015a; Shelden et al. 2017; Shelden et al. 2013).

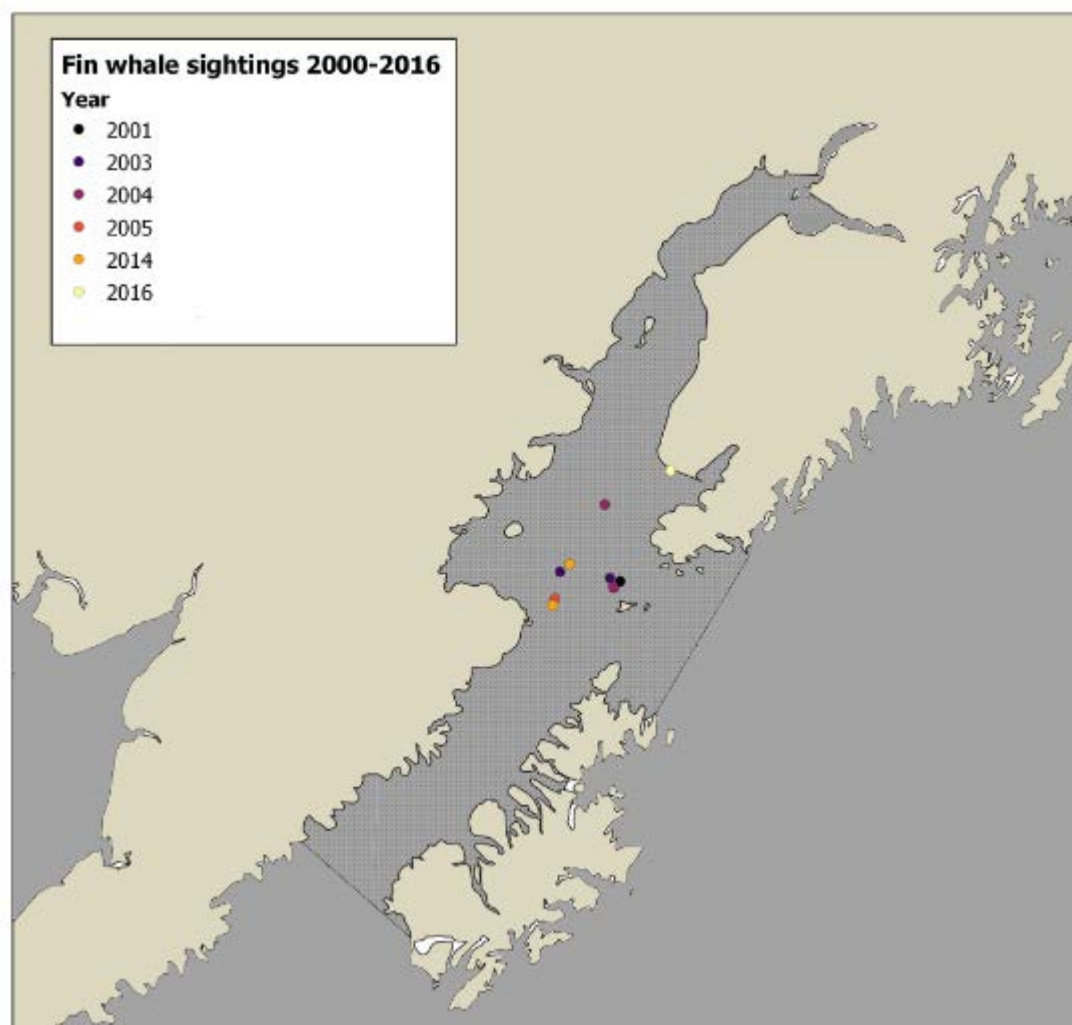


Figure 60. Fin whale sightings during aerial surveys for belugas from 2000-2016 (no fin whales were seen during 2000, 2002, 2006-2013)(Rugh et al. 2000, Rugh et al. 2005, Shelden et al. 2013, Shelden et al. 2015a, Shelden et al. 2017).

For this action, the density of fin whales in Cook Inlet was estimated as 0.00033 whales/km² using sightings from the NMFS aerial surveys conducted for beluga whales in June between

2000 and 2016 (Rugh et al. 2000, Rugh et al. 2005, Shelden et al. 2013, Shelden et al. 2015a, Shelden et al. 2017). Although there are a number of caveats to using these survey data for estimating density of species other than belugas (see Section 6 for a discussion of these caveats), they represent the best available dataset for marine mammal sightings in Cook Inlet.

Feeding and Prey Selection

In the North Pacific, fin whales prefer euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristatus*), followed by schooling fish such as herring, walleye pollock (*Theragra chalcogramma*), and capelin (Kawamura 1980; Nemoto 1970). Feeding may occur in shallow waters on prey such as sand lance (Overholtz and Nicolas 1979) and herring (Nøttestad et al. 2002), but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Panigada et al. 2008).

Fin whales, like humpback and blue whales, exhibit lunge-feeding behavior, where large amounts of water and prey are taken into the mouth and filtered through the baleen (Brodie 1993; Goldbogen et al. 2008; Goldbogen et al. 2006).

The percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5 to 20 shallow dives with each of these dive lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Hain et al. 1992; Watkins 1981). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001). However, Lafortuna et al. (2003) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known to occur (Panigada et al. 1999).

Hearing, Vocalizations, and Other Sensory Capabilities

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10 to 200 Hz band (Edds 1988; Thompson et al. 1992; Watkins 1981; Watkins et al. 1987). The most typical signals are long, patterned sequences of short duration (0.5 to 2 s) infrasonic pulses in the 18 to 35 Hz range (Patterson and Hamilton 1964). Estimated source levels for fin whales are 140 to 200 dB re 1 μ Pa m (Clark and Gagnon 2004; McDonald et al. 1995; Patterson and Hamilton 1964; Thompson et al. 1992; Watkins et al. 1987). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark 1998). Short sequences of rapid pulses in the 20 to 70 Hz band are associated with animals in social groups (McDonald et al. 1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins et al. 1987), while the individual counter calling data of McDonald et al. (1995) suggest that the more variable calls are contact calls. Some authors feel there are

geographic differences in the frequency, duration, and repetition of the pulses (Thompson et al. 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources (see the review by Thompson et al. (1992) for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, or baleen whales, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Edds-Walton 1997; Payne and Webb 1971). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

While there is no direct data on hearing in low-frequency cetaceans, the applied frequency range is anticipated to be between 7 Hz and 35 kHz (NMFS 2018c). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic (low pitch) hearing. Synthetic audiograms produced by applying models to X-ray computed tomography scans of a fin whale calf skull indicate the range of best hearing for fin whale calves to range from approximately 0.02 to 10 kHz, with maximum sensitivities between 1 to 2 kHz (Cranford and Krysl 2015).

4.3.7 Sperm Whale

Status and Population Structure

The sperm whale listed as an endangered species in 1970 (35 FR 18319) under the ESCA following widespread significant depletions due to commercial whaling and continued to be listed as endangered following passage of the ESA (39 FR 41367). A recovery plan was prepared in 2010 (NMFS 2010c). Critical habitat has not been designated for this species.

The sperm whale is one of the most widely distributed marine mammals (Muto et al. 2017). Currently, the population structure of sperm whales has not been adequately defined (NMFS 2010c). For management purposes under the MMPA, three stocks of sperm whale are currently recognized in U.S. waters of the Pacific Ocean: (1) Alaska (also termed North Pacific stock), (2) California/Washington/Oregon, and (3) Hawaii (Muto et al. 2017). The North Pacific stock is the only stock occurring in Alaska waters (Muto et al. 2017).

Whitehead (2002) estimated the global abundance of sperm whales at 1,110,000 animals prior to commercial whaling. Rice (1989) estimated the North Pacific stock at 1,260,000 animals prior to exploitation (which is larger than the estimate from Whitehead and Arnborn (1987) for the global population), and estimated that by the 1970s, the North Pacific stock had been reduced to 930,000 whales. Although the number of sperm whales occurring in Alaska waters is unknown, 102,112 sperm whales are estimated to occur in the western North Pacific region (Kato and

Miyashita 1998). There is no current reliable estimate of the global abundance of sperm whale, or of the North Pacific stock in Alaska, and therefore the population trend of sperm whales in the North Pacific stock is also unknown (Muto et al. 2017).

Distribution

Sperm whales are the largest of the odontocetes (toothed whales), inhabit all oceans worldwide, and can be observed along the pack ice edge in both hemispheres. They are most commonly found in deep ocean waters (typically deeper than 900 feet) between latitudes 60° N and 60° S. In the North Pacific the northernmost boundary for sperm whales extends from Cape Navarin, Russia (latitude 62° N) to the Pribilof Islands, Alaska (Figure 61)(Allen and Angliss 2014; Omura 1955).

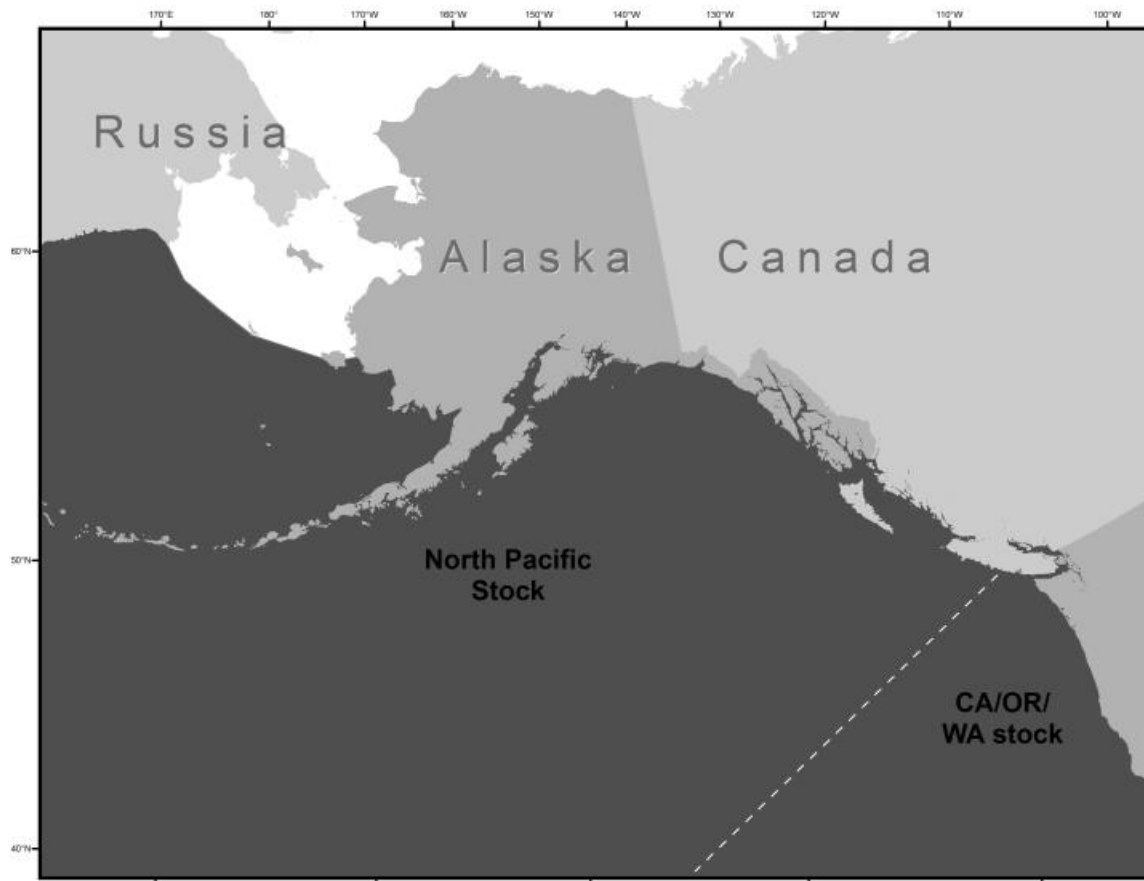


Figure 61. The approximate distribution of sperm whales in the North Pacific includes deep waters south of 62°N to the equator (from (Muto et al. 2018)).

Occurrence in the Action Area

In the proposed action area sperm whales commonly occur in the Gulf of Alaska, Bering Sea, around the Aleutian Islands, and some parts of Southeast Alaska during the summer months (Muto et al. 2017). Sperm whales occur year round in the Gulf of Alaska, but appear to be more common during the summer months than winter months (Mellinger et al. 2004). Between 2001

and 2019 around the central and western Aleutian Islands, sighting surveys conducted by the NMFS Marine Mammal Laboratory showed that sperm whales were the most frequently sighted large whale species (MML, unpubl. data). Sperm whales are thought to migrate to higher latitude foraging grounds in the summer and lower latitudes in the winter (Muto et al. 2017).

Feeding and Prey Selection

Sperm whales are among the deepest marine mammal divers. Males have been known to dive 3,936 ft (1,199.7 m) while females dive to at least 3,280 ft (999.7 m), and dives can last for more than an hour.

Giant squid comprise about 80 percent of the sperm whale diet and the remaining 20 percent is comprised of octopus, fish, shrimp, crab, and even small bottom-living sharks. Sperm whales can consume about 3–3.5 percent of their body weight in a day. Sperm whales show evidence of disk-shaped scars and wounds likely made by giant squid resisting capture.

Hearing, Vocalization, and Other Sensory Capabilities

Sound production and reception by sperm whales are better understood than for most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (peak sound source levels of 200-236 dB re 1 μ Pa), although lower average source level energy has been suggested at around 171 dB re 1 μ Pa (Møhl et al. 2003; Weilgart and Whitehead 1993). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford et al. 1996).

Our understanding of sperm whale hearing stems largely from the sounds they produce. In addition, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echo-sounders and submarine sonar (Watkins et al. 1985). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency noise in the ocean. Sperm whales are in the mid-frequency (MF) cetaceans functional hearing group (Southall et al. 2007).

5 ENVIRONMENTAL BASELINE

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action areas that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency’s discretion to modify are part of the environmental baseline (50 CFR § 402.02). This section discusses the environmental baseline, focusing on existing anthropogenic

and natural activities within the action area and their influences on listed species and their critical habitat that may be adversely affected by the proposed action.

5.1 Climate Change

All portions of the proposed project action area (Prudhoe Bay, the marine transit route, and Cook Inlet) are being influenced by climate change. In this section, we first address broad changes in climate, followed by more specific information and examples for the different portions of the action area.

Since the 1950s the atmosphere and oceans have warmed, snow and sea ice have diminished, sea levels have risen, and concentrations of greenhouse gases have increased (IPCC 2013). While both natural and anthropogenic factors have influenced this warming, human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2013). In marine ecosystems, shifts in temperature, ocean circulation, stratification, nutrient input, oxygen content, and ocean acidification are associated with climate change and increased atmospheric carbon dioxide (Doney et al. 2012), and these shifts have potentially far-reaching biological effects. The impacts of climate change are especially pronounced at high latitudes.

Average temperatures have increased across Alaska at more than twice the rate of the rest of the United States³. In the past 60 years, average air temperatures across Alaska have increased by approximately 1.65°C (3°F), and winter temperatures have increased by 3.3°C (6°F) (Chapin et al. 2014). In August 2017, sea surface temperatures in the Barents and Chukchi seas were up to 3.96°C (7.2°F) warmer than the 1982-2010 average August temperatures⁴. Some of the most pronounced effects of climate change in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean temperatures and chemistry (Chapin et al. 2014).

Arctic summer sea ice is receding faster than previously projected and is expected to virtually disappear before mid-century (Chapin et al. 2014). The NOAA 2017 Arctic Report Card states that the Arctic “shows no sign of returning to the reliably frozen region of recent past decades.” While a changing climate may create opportunities for range expansion for some wide-ranging generalist species, the life cycles and physiological requirements of many specialized polar species are closely linked to the annual cycles of sea ice and photoperiod (Doney et al. 2012). Thus, the loss of sea ice may alter marine ecosystems and reduce habitat for ice-associated species such as listed bearded seals and ringed seals in ways to which they cannot adapt at the rate the changes are occurring. Additionally, the loss of sea ice increases the potential for further anthropogenic impacts as vessel traffic for transportation and tourism and resource extraction activities move into newly ice-free regions.

Increasing ocean temperature, decreasing seasonal ice cover and extent, and increasing freshwater content in Alaska’s oceans are changing ocean currents and stratification, nutrient cycles, upwelling, food webs, species composition, primary and secondary productivity, species distributions, and predator-prey interactions (Doney et al. 2012). The impacts of these changes

³ NOAA. <https://arctic.noaa.gov/Report-Card/Report-Card-2019/ArtMID/7916/ArticleID/835/Surface-Air-Temperature>. Accessed May 20, 2020.

⁴ NOAA. <http://www.arctic.noaa.gov/Report-Card/Report-Card-2017>, Accessed December 14, 2017.

and their interactions on listed species in Alaska are hard to predict.

For 650,000 years or more, the average global atmospheric carbon dioxide concentration varied between 180 and 300 parts per million (ppm), but since the beginning of the industrial revolution in the late 1700s, atmospheric CO₂ concentrations have been increasing rapidly, primarily due to anthropogenic inputs (Fabry et al. 2008). The world's oceans have absorbed approximately one-third of the anthropogenic CO₂ released, which has curtailed the increase in atmospheric CO₂ concentrations (Sabine et al. 2004). Despite the oceans' role as large carbon sinks, in 2016, the mean monthly average atmospheric CO₂ level exceeded 400 ppm and continues to rise (Figure 62).

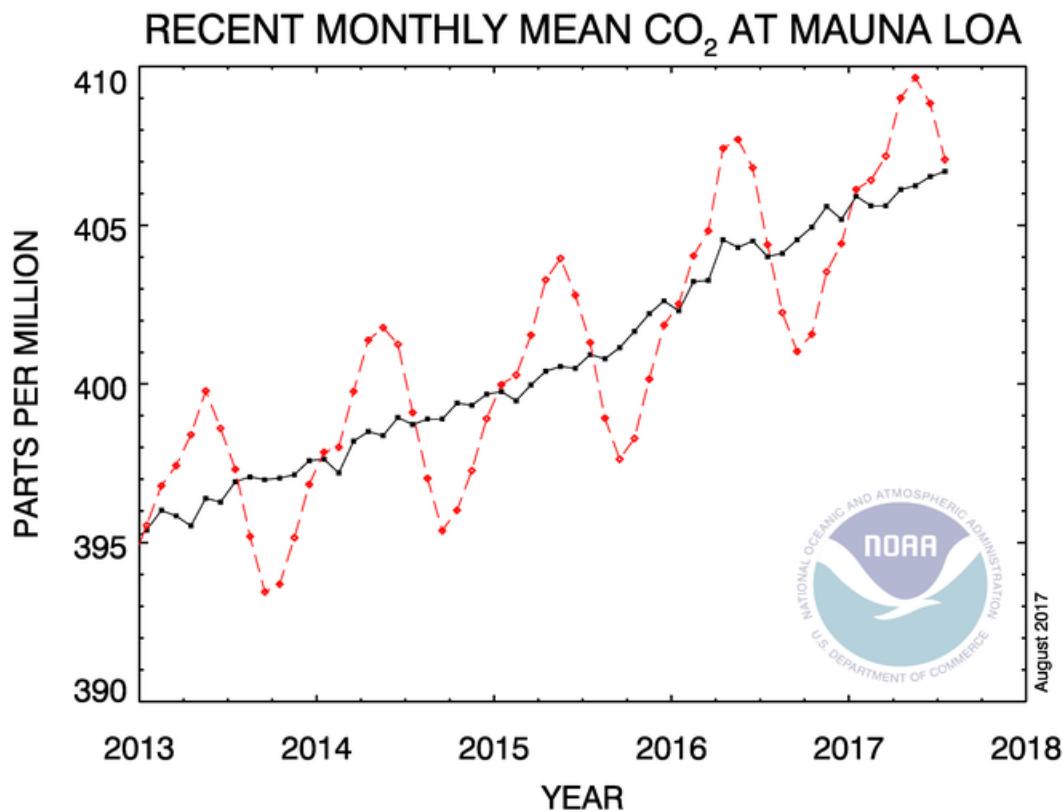


Figure 62. Monthly mean atmospheric carbon dioxide concentrations measured at Mauna Loa Observatory, Hawaii. (Data from NOAA Earth System Research Laboratory, Global Monitoring Division, available at <https://www.esrl.noaa.gov/gmd/ccgg/trends/index.html>, accessed August 7, 2017).

As the oceans absorb more CO₂, the pH of seawater is reduced. This process is commonly referred to as ocean acidification. Ocean acidification reduces the saturation states (Ω) of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals ($\Omega > 1$), calcification (growth) of shells is favored. Likewise, when $\Omega < 1$, dissolution is favored (Feely et al. 2009).

High latitude oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters (Fabry et al. 2009; Jiang et al. 2015), making Alaska's oceans more susceptible to the effects of ocean acidification. Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice reduce the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite has been detected in the Bering Sea at sampling stations near the outflows of the Yukon and Kuskokwim rivers (Fabry et al. 2009), Glacier Bay (Reisdorph and Mathis 2014), and the Chukchi Sea (Fabry et al. 2009). By 2050, all of the Arctic Ocean is predicted to be undersaturated with respect to aragonite (Feely et al. 2009).

Ocean acidification may cause a variety of species- and ecosystem-level effects in high latitude ecosystems. Species-level effects may include reductions in the calcification rates of numerous planktonic and benthic species, alteration of physiological processes such as pH buffering, hypercapnia, ion transport, acid-base regulation, mortality, metabolic suppression, inhibited blood-oxygen binding, and reduced fitness and growth (Fabry et al. 2008). Ecosystem effects could include altered species compositions and distributions, trophic dynamics, rates of primary productivity, and carbon and nutrient cycling (Fabry et al. 2008).

Additionally, as the ocean becomes more acidic, low frequency sounds (1-3 kHz and below) travel farther because the concentrations of certain ions that absorb acoustic waves decrease with decreasing pH (Brewer and Hester 2009).

5.1.1 Prudhoe Bay

The main concern regarding the conservation status of ringed and bearded seals stems from the likelihood that their sea ice habitat is being modified by the warming climate and that the scientific consensus projects accelerated warming in the foreseeable future. A second concern, also associated with the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem (75 FR 77496, 77502; December 10, 2010). According to climate model projections, snow cover on sea ice is forecasted to be inadequate for the formation and occupation of birth lairs for ringed seals within this century over the Alaska stock's entire range (Kelly et al. 2010b). A decrease in the availability of suitable sea ice conditions may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in seal populations (Loeng et al. 2005). Changes in snowfall over the 21st century were projected to reduce areas of sea ice with suitable snow depths for ringed seal lairs by 70 percent (Hezel et al. 2012).

Bearded seals are mostly found in areas where seasonal sea ice occurs over relatively shallow waters where they are able to forage on the bottom (Fedoseev 2000), though young seals may be found in ice-free areas such as bays and estuaries. Although no scientific studies have directly addressed the impacts of ocean acidification on ringed or bearded seals, ocean acidification will likely affect their ability to find food. The decreased availability or loss of prey species from the ecosystem may have cascading trophic effects on ringed (Kelly et al. 2010b) and bearded seals. Some of the anticipated biological consequences of the changing Arctic conditions are shown in Table 39.

However, not all Arctic species are likely to be adversely influenced by global climate change. Conceptual models suggested that overall reductions in sea ice cover should increase the Western Arctic stock of bowhead whale prey availability (Moore and Laidre 2006). This theory may be substantiated by the steady increase in the Western Arctic bowhead population during the nearly 20 years of sea ice reductions (Walsh 2008). As mentioned in Section 4.2, George et al. (2006), showed that harvested bowheads had better body condition during years of light ice cover. Similarly, George et al. (2015b) found an overall improvement in bowhead whale body condition and a positive correlation between body condition and summer sea ice loss over the last 2.5 decades in the Pacific Arctic. George et al. (2015a) speculated that sea ice loss has positive effects on secondary trophic production within the Western Arctic bowhead whale's summer feeding region. Moore and Huntington (2008) anticipated that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change.

Table 39. Summary of possible direct and indirect effects for Arctic marine mammals (focus on seals) related to climate change (adapted from (Burek et al. 2008))

Effect	Result
Direct	
Loss of sea ice platform	Reduction of suitable habitat for feeding, resting, molting, breeding. Movement and distribution will be affected
Changes in weather	Reduction in snow on sea ice, loss of suitable lair habitat
Ocean acidification	Alterations of prey base
Indirect	
Changes in infectious disease transmission (changes in host–pathogen associations due to altered pathogen transmission or host resistance)	Increased host density due to reduced habitat, increasing density-dependent diseases. Epidemic disease due to host or vector range expansion. Increased survival of pathogens in the environment. Interactions between diseases, loss of body condition, and increased immunosuppressive contaminants, resulting in increased susceptibility to endemic or epidemic disease.
Alterations in the predator–prey relationship	Affect body condition and, potentially, immune function.
Changes in toxicant pathways (harmful algal blooms, variation in long-range transport, biotransport, runoff, use of the Arctic)	Mortality events from biotoxins Toxic effects of contaminants on immune function, reproduction, skin, endocrine systems, etc.
Other negative anthropogenic impacts related to longer open water period	Increased likelihood of ship strikes, fisheries interactions, acoustic injury Chemical and pathogen pollution due to shipping or agricultural practices. Introduction of nonnative species

5.1.2 Marine Transit Route

Climate change and its effects on seasonal ice area are affecting the marine transit route through the Bering, Chukchi, and Beaufort seas.

The past two winters (2017–18 and 2018–19) have seen “marine heat waves” in the Bering Sea (Thoman and Walsh 2019). The heat content of the entire water column was greater in 2018 than ever recorded. In 2018–2019, the April sea ice in the Bering Sea was a small fraction of its historical extent. A NOAA cruise in 2018 found no ribbon or spotted seals in their historically preferred breeding areas (NOAA 2019). The “cold pool” of water usually near the bottom of the Bering Sea disappeared during this time. This disappearance has major implications for the region, as the cold pool served as a barrier to northward migration of various aquatic species (Thoman and Walsh 2019). There have also been increases of subarctic species seasonally found in the Chukchi Sea. With increasing sea-surface temperatures in the Arctic, and the loss of the cold water pool, the potential northward movement of sub-Arctic and non-native species increases (Nordon 2014).

5.1.3 Cook Inlet

The physical environment of Cook Inlet is shifting, with a reduction in duration of seasonal sea ice. In Cook Inlet, mesozooplankton biomass increased each year from 2004 to 2006; however, sampling from late 2006 to early 2007 suggests biomass values are decreasing (Batten et al. 2018), a change the authors suggest was driven by changes in climate. Changes in temperature affect zooplankton abundance, which in turn may influence fish species composition, and hence, the quality and types of fish available for marine mammals.

Beluga whales seasonally breed and feed in nearshore waters during the summer, but are ice-associated during the remaining part of the year. Ice floes can offer protection from predators and, in some regions, support prey, such as ice-associated cod. Moore and Huntington (2008) suggested that belugas and other ice-associated marine mammals might benefit from warmer climates as areas formerly covered ice would be available to forage. However, given the limited winter prey available in upper Cook Inlet (where ice predominates during winter), less winter ice might not benefit Cook Inlet beluga whales.

An additional indirect threat of climate change to belugas may be the fact that regional warming could lead to increased human activity. Less ice would mean increased vessel activity with an associated increase in noise, pollution, and risk of ship strike. Other factors include changing prey composition, increased killer whale predation due to lack of ice refuge, increased susceptibility to ice entrapment due to less predictable ice conditions, and increased competition with co-predators. Specific to Cook Inlet beluga whales, the greatest climate change risks would likely be potential changes in salmon and eulachon abundance, and any increase in winter susceptibility to killer whale predation. Also, more rapid melting of glaciers might change the silt deposition in the Susitna Delta, potentially altering habitat for prey (NMFS 2008a). However, the magnitude of these potential effects is unpredictable.

Whether recent increases in the presence of humpback whales in Cook Inlet can be attributed to climate change, whale population growth, both, or other factors remains speculative. There is no

clear trend in the number of humpback whale sightings in lower Cook Inlet between 2004 and 2016 (Figure 47). Climate-driven changes in glacial melt are presumed to have profound effects on seasonal streamflow within the Cook Inlet drainage basin, affecting both anadromous fish survival and reproduction in unpredictable ways. Changes in glacial outwash will also likely affect the chemical and physical characteristics of Cook Inlet's estuarine waters, possibly changing the levels of turbidity in the inlet. Whether such a change disproportionately benefits marine mammals, their prey, or their predators is unknown.

Cook Inlet beluga whale critical habitat may be affected by climate change and other large-scale environmental phenomena including the Pacific Decadal Oscillation (a long-lived El Niño-like climate variability that may persist for decades) and ecological regime shifts. Climate change can potentially affect prey availability, glacial output and siltation, and salinity and acidity in downstream estuarine environments (NMFS 2010a; NMFS 2016b). The Pacific Decadal Oscillation may influence rainfall, freshwater runoff, water temperature, and water column stability. Ecological regime shifts, in which species composition is restructured, have been identified in the North Pacific (Anderson and Piatt 1999; Hare and Mantua 2000; Hollowed and Wooster 1992) and are believed to have affected prey species availability in Cook Inlet and the North Pacific. These events may result in seasonal and spatial changes in prey abundance and distribution and could affect the conservation value of designated critical habitat for Cook Inlet beluga whales.

5.2 Fisheries

Worldwide, fisheries interactions have an impact on many marine mammal species. More than 97 percent of whale entanglements are caused by derelict fishing gear (Baulch and Perry 2014). There is also concern that mortality from entanglement may be underreported, as many marine mammals that die from entanglement tend to sink rather than strand ashore. Entanglement may also make marine mammals more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed.

Entanglement of pinnipeds and cetaceans in fishing gear and other human-made material is a major threat to their survival worldwide. Other materials also pose entanglement risks including marine debris, mooring lines, anchor lines, and underwater cables. While in many instances marine mammals may be able to disentangle themselves (Jensen et al. 2009), other entanglements result in lethal and sublethal trauma to marine mammals including drowning, injury, reduced foraging, reduced fitness, and increased energy expenditure (van der Hoop et al. 2016).

Entangled marine mammals may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/ or be hit by vessels due to an inability to avoid them.

Entanglement can include many different gear interaction scenarios, but the following have occurred with listed species covered in this opinion:

- Ingestion of gear and/or hooks can cause serious injury depending on whether the gear works its way into the gastrointestinal tract, whether the gear penetrates the gastrointestinal tract lining, and the location of the hooking (e.g., embedded in the animal's stomach or other internal body parts) (Andersen et al. 2008).

- Gear loosely wrapped around the marine mammal's body that moves or shifts freely with the marine mammal's movement and does not indent the skin can result in disfigurement.
- Gear that encircles any body part and has sufficient tension to either indent the skin or to not shift with marine mammal's movement can cause lacerations, partial or complete fin amputation, organ damage, or muscle damage and interfere with mobility, feeding, and breathing. Chronic tissue damage from line under pressure can compromise a whale's physiology. Fecal samples from entangled whales had extremely high levels of cortisol (Rolland et al. 2005), an immune system hormone. Extended periods of pituitary release of cortisol can exhaust the immune system, making a whale susceptible to disease and infection.

Additionally, commercial fisheries may indirectly affect whales and seals by reducing the amount of available prey or affecting prey species composition. In Alaska, commercial fisheries target known marine mammal prey species, such as pollock and cod, and bottom-trawl fisheries may disturb habitat for bottom-dwelling prey species of marine mammals.

Due to their highly migratory nature, many species considered in this Opinion have the potential to interact with fisheries both in and outside of the action area. Assessing the impact of fisheries on such species is difficult due to the large number of fisheries that may interact with the animals and the inherent complexity of evaluating ecosystem-scale effects. The NMFS Bycatch Report estimates bycatch of marine mammals (and other taxa) from observer data and self-reported logbook data (NMFS 2016d). Additionally, under the MMPA, NMFS maintains an annual List of Fisheries that categorizes U.S. commercial fisheries according to the level of interactions that result in incidental mortality or serious injury of marine mammals. Detailed information on U.S. commercial fisheries in Alaska waters, including observer programs and coverage and observed incidental takes of marine mammals, is presented in Appendices 3-6 of the Alaska Stock Assessment Reports (Muto et al. 2017).

5.2.1 Prudhoe Bay

The North Pacific Fishery Management Council adopted an Arctic Fishery Management Plan (FMP) which closed all Federal waters of the Chukchi and Beaufort seas to commercial fishing for any species of finfish, mollusks, crustaceans, and all other forms of marine animal and plant life, with limited exceptions. The Arctic FMP does not regulate subsistence or recreational fishing or State of Alaska-managed fisheries in the Arctic.

Because no commercial fisheries occur in the Chukchi and Beaufort Seas, any observed serious injury or mortality to listed species in the Arctic that can be associated with commercial fisheries is currently attributable to interactions with fisheries in other areas, including in the Bering Sea/Aleutian Islands management area (BSAI) and Gulf of Alaska (GOA). For example, George et al. (2017) analyzed scarring data for bowhead whales harvested between 1990 and 2012 to estimate the frequency of line entanglement. Approximately 12 percent of the harvested whales examined for signs of entanglement (59/486) had scar patterns that were identified with high confidence as entanglement injuries (29 whales with possible entanglement scars were excluded). Most of the entanglement scars occurred on the peduncle, and entanglement scars were rare on smaller subadult and juvenile whales (body length <10 m). The authors suspected

the entanglement scars were largely the result of interactions with derelict fishing/crab gear in the Bering Sea. The estimate of 12 percent entanglement does not include bowheads that may have died as a result of entanglement.

5.2.2 Marine Transit Route

Groundfish fisheries (including pollock, cod, flatfish, sablefish, rockfish, and other species) of the BSAI and GOA are managed under separate but complementary fishery management plans (FMPs) developed by the North Pacific Fishery Management Council. By regulation, up to 2 million metric tons of groundfish may be harvested annually from the BSAI, and up to 800,000 metric tons of groundfish may be harvested annually from the GOA (50 CFR 679.20(a)). In 2018, 2 million metric tons of groundfish were authorized for harvest in the BSAI, and approximately 427,000 metric tons of groundfish were authorized for harvest in the GOA. Nearly 80 percent of the halibut apportioned to Alaska under the Pacific Halibut Treaty is allocated to fisheries in the Gulf of Alaska (including Southeast Alaska). The remainder is allocated and harvested in the BSAI.

NMFS manages 10 stocks of crab in the BSAI under an FMP, and the State of Alaska manages the remaining crab stocks. Pot gear is the primary gear type used in the directed crab fisheries. In 2016, more than 29,000 metric tons of crab were harvested in the Federal crab fisheries in the BSAI (Garber-Yonts and Lee 2017).

5.2.2.1 Entanglement

There are no Federal Fishery Observer Program records of bowhead whale mortality incidental to U.S. commercial fisheries in Alaska. However, in early July 2010 a dead bowhead whale was found floating in Kotzebue Sound entangled in crab pot gear similar to that used by commercial crabbers in the Bering Sea (Suydam et al. 2011); and during the 2011 spring aerial photographic survey of bowhead whales near Point Barrow, an entangled bowhead whale was photographed that was not considered to be seriously injured (Mocklin et al. 2012). Citta et al. (2014) found that the distribution of satellite-tagged bowhead whales in the Bering Sea overlapped spatially and temporally with areas where commercial pot fisheries occurred and noted the potential risk of entanglement in lost gear. The minimum estimated average annual mortality and serious injury rate in U.S. commercial fisheries in 2010 through 2014 is 0.2 bowhead whales (Muto et al. 2018); however, the actual rate is currently unknown. As mentioned in Section 5.2.1, George et al (2017) found evidence of past entanglements (entanglement scars). This is thought to be an underestimate, as animals killed as a result of entanglement are no longer part of this sampled population.

Humpback whales can be killed or injured during interactions with commercial fishing gear, although the evidence available suggests that the frequency of these interactions may not have significant adverse consequence for humpback whale populations. Most humpbacks get entangled with gear between the beginning of June and the beginning of September, when they are on their nearshore foraging grounds in Alaska waters. Between 1990 and 2016, 29 percent of humpback entanglements were with pot gear and 37 percent with gillnet gear. Longline gear comprised only 1-2 percent of all humpback fishing gear interactions. A photographic study of

humpback whales in southeastern Alaska in 2003 and 2004 found at least 53 percent of individuals showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005).

During 2010-2014, mortality and serious injury of humpback whales occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (1 each in 2010 and 2012) and the Bering Sea/Aleutian Islands flatfish trawl fishery (1 in 2010). The estimated average annual mortality and serious injury rate from observed U.S. commercial fisheries is 0.6 Western North Pacific DPS humpback whales in 2010-2014 (Muto et al. 2018). There are no known occurrences of fishery-related take of humpback whales in the action area.

5.2.2.2 Competition for Prey

Whale species, including both DPSs of humpback whales, fin whales, and sperm whales considered in this biological opinion, may compete with fisheries for prey species such as pollock and cod (Baker 1985; Geraci et al. 1989; Hain et al. 1982; Kawamura 1980; Nemoto 1970). These whale species also feed on a variety of other species, some of which are not commercially or recreationally viable fisheries. As it is unknown how much of the humpback and fin whale diets consists of species exploited by commercial fisheries along the marine transit route, we cannot assess the degree to which competition for prey with fisheries affects these large whale species, but we have no indication that this is a serious concern.

5.2.3 Cook Inlet

Cook Inlet supports several commercial fisheries, all of which require permits. The commercial fisheries in Cook Inlet are divided into the upper and lower Cook Inlet. The upper Cook Inlet commercial fishing region consists of all waters north of Anchor Point and is further divided into the Northern (north of the West and East Foreland) and Central Districts (south of the Forelands to Anchor Point Light). Species commercially harvested in upper Cook Inlet include all five Pacific salmon species (drift and set gillnet), eulachon or smelt (dipnet), Pacific herring (gillnet), and razor clams (hand-digging); however, sockeye (red) salmon are the most economically valuable (Shields and Dupuis 2017).

In 2016, approximately 3.0 million salmon were harvested commercially in upper Cook Inlet, which is under the average annual harvest from 1966-2016 (3.5 million salmon) (Shields and Dupuis 2017). Approximately 95.8 tons of eulachon (100 tons is the maximum allowable harvest), 22.9 tons of herring, and 285,000 pounds of razor clams were commercially harvested in 2016 (Shields and Dupuis 2017).

Recreational fisheries exist in the river systems on the western Kenai Peninsula for salmon (king, silver, red, and pink), both freshwater and marine Dolly Varden char, and both freshwater rainbow trout and steelhead trout. In the marine waters throughout Cook Inlet, recreational fishing occurs for salmon (king and silver), Pacific cod, and halibut. Many of the charter fishing vessels targeting salmon and halibut operate out of Homer, in lower Cook Inlet.

NMFS assumes that ADFG will continue to manage fish stocks and monitor and regulate fishing in Cook Inlet to maintain sustainable stocks. An important remaining unknown is the extent to which Cook Inlet marine mammal prey is made less available due to commercial, subsistence, personal use, and sport fishing either by direct removal of the prey or by human-caused habitat

avoidance. Gathering data on this threat near the mouths of salmon and eulachon spawning streams is especially important.

Potential impacts from commercial, personal-use and recreational fishing on Cook Inlet beluga whales and to a lesser extent, humpback whales, include vessel strikes, harassment, gear entanglement, reduction of prey and prey availability, and displacement from important habitat. For example, the Kenai River is the most heavily-fished river in Alaska, while historically also important foraging habitat for Cook Inlet beluga whales (e.g., waters within and near the outlets of the Kenai and Kasilof Rivers during salmon season) (Ovitz 2019).

5.2.3.1 Entanglement

Prior to the mid-1980s, the only reports of fatal takes of belugas incidental to entanglement in fishing gear in Cook Inlet are from the literature (Burns and Seaman 1986; Murray and Fay 1979). While there have been sporadic reports since the mid-1980s of single belugas becoming entangled in fishing nets, the only known mortality associated with entanglement in a fishing net was from a young Cook Inlet beluga carcass recovered from a subsistence set net in 2012.

Overall, the current rate of direct mortality from fisheries in Cook Inlet appears to be minor. There have been reports of non-lethal entanglement of Cook Inlet belugas. For example, in 2005, a Cook Inlet beluga entangled in an unknown object, perhaps a tire rim or a culvert liner, was photographed in Eagle Bay (McGuire et al. 2013), and another Cook Inlet beluga was repeatedly photographed 2010–2013 with what appeared to be a rope entangled around the upper portion of its body near the pectoral flippers (McGuire et al. 2014). It is not known if these animals were able to disentangle themselves or if they died as a result of the entanglements (NMFS 2016b).

An observer program for the Cook Inlet salmon set and drift gillnet fisheries was implemented in 1999 and 2000 in response to the concern that there may be significant numbers of marine mammal injuries and mortalities that occur incidental to these fisheries. Observer coverage in the Cook Inlet drift gillnet fishery was 1.75 percent and 3.73 percent in 1999 and 2000, respectively. The observer coverage in the Cook Inlet set gillnet fishery was 7.3 percent and 8.3 percent in 1999 and 2000, respectively (Manly 2006).

5.2.3.2 Competition for Prey

Fisheries in Cook Inlet have varying likelihoods of competing with marine mammals for fish depending on gear type, species fished, timing, and fisheries location and intensity. For Cook Inlet beluga whales, there is a possibility of reduced prey availability and/or habitat displacement due to commercial and recreational fishing activity. The operation of watercraft near the mouths and deltas of rivers entering Cook Inlet, Turnagain Arm, and Knik Arm can affect beluga whales, hindering them from using these waters in pursuit of eulachon and salmon prey. For example, while NMFS has numerous reports of beluga whales in the Kenai River prior to and after the summer salmon fishing season, they have not been observed in or near the river in recent times when salmon runs are strong and fishing activity (commercial, recreational, and personal use) is high (Castellote et al. 2015; Sheldon et al. 2015b). Small watercraft have been observed harassing belugas out of the 20-mile River in Turnagain Arm, and within the Kenai River.

There is strong indication that Cook Inlet beluga whales are dependent on access to relatively dense concentrations of high value prey species, particularly in the spring and throughout the

summer months. Norman (2011) estimated that the total biomass of fish consumed by 350 Cook Inlet beluga whales during the summer would be approximately 1250 metric tons. Chum, coho, and other salmonid species constitute >54 percent of the Cook Inlet beluga whales' summer diet (Hobbs and Shelden 2008). A significant reduction in the amount of available prey could impact the energetics for Cook Inlet beluga whales and delay recovery.

There is no known information summarizing interactions between fishing in Cook Inlet and large cetaceans. Prey competition is unlikely to occur, as the important foraging areas for humpback, fin, and sperm whales are outside of Cook Inlet.

5.3 Oil & Gas Development and Exploration

Offshore oil and gas development in Alaska poses a number of threats to listed marine species, including increased ocean noise, risk of hydrocarbon spills, production of waste liquids, habitat alteration, increased vessel traffic, and risk of ship strike.

Seismic oil and gas surveying, one of the loudest man-made underwater noise sources (Richardson et al. 1995) has acoustic impacts on the marine environment. The noise generated from seismic surveys has been linked to behavioral disturbance of wildlife, masking of cetacean communication, and potential auditory injury to marine mammals in the marine environment (Smith et al. 2017). More information about the effects of noise from oil and gas exploration and seismic activity can be found in the *Ambient and Anthropogenic Noise* (Section 5.5).

Seismic surveys are often followed by test drilling. Test drilling involves fewer direct impacts than seismic exploration, but the potential risks of test drilling, such as oil spills, may have broader consequences (Smith et al. 2017).

Oil and gas exploration, including seismic surveys, occur within the action area and across the ranges of many of the species considered in this Biological Opinion.

5.3.1 Prudhoe Bay

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the Outer Continental Shelf (OCS) of the Beaufort and Chukchi Sea Planning Areas, in Canada's eastern Beaufort Sea off the Mackenzie River Delta, in Canada's Arctic Islands, and in the Russian Arctic, and around Sakhalin Island in the Sea of Okhotsk (NMFS 2016a). In the central Beaufort Sea in Alaska, oil and gas exploration, development, and production activities include, but are not limited to: seismic surveys; exploratory, delineation, and production drilling operations; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations. Stressors associated with these activities that are of primary concern for marine mammals include noise (discussed in *Ambient and Anthropogenic Noise* (Section 5.5)), physical disturbance, and pollution, particularly in the event of a large oil spill.

Oil and gas exploration activities have occurred on the North Slope since the early 1900s, and oil production started at Prudhoe Bay in 1977. Oil production has occurred for over 40 years in the region, and presently spans from the Alpine-field, which is approximately 96 km (60 mi) west of

Prudhoe Bay, to the Point Thomson project, which is approximately 96 km east of Prudhoe Bay. Additionally, onshore gas production from the Barrow gas field began over 60 years ago. Associated industrial development has included the creation of industry-supported community airfields at Deadhorse and Kuparuk, and an interconnected industrial infrastructure that includes roadways, pipelines, production and processing facilities, gravel mines, and docks.

In 1977, the Trans-Alaska Pipeline System began to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska. Today, it continues to transport the North Slope's entire onshore and offshore oil production, and it is projected to do so for years into the future. Endicott Satellite Drilling Island, built in 1987, was constructed to support the first continuous production of oil from an offshore field in the Arctic. Subsequently, the Northstar offshore island was constructed in 1999 and 2000 to support oil production. Northstar, as well as the Nikaitchuq and Oooguruk developments, currently operates in nearshore areas of the Beaufort Sea, and is expected to continue operating in the future. Other oil and gas related activities that have occurred in the Beaufort Sea and Chukchi Sea OCS to date include exploratory drilling, exploration seismic surveys, geohazard surveys, geotechnical sampling programs, and baseline biological studies and surveys. There are also several exploration and development projects occurring on the North Slope including Greater Moose's Tooth 1 and 2, Smith Bay, Nuna, and Nanushuk. In addition, the Alaska Gasoline Development Corporation is developing the Alaska Stand-Alone Gas Pipeline that would extend from the North Slope to Southcentral Alaska. The project would include barging to the North Slope and modifications to West Dock.

Since 1975, 84 exploration wells, 14 continental offshore stratigraphic test wells, and six development wells have been drilled on the Arctic OCS (BOEM 2012). Historical data on offshore oil spills for the Alaska Arctic OCS region consists of all small spills (i.e., less than 1,000 barrels [31,500 gallons]) and cannot be used to create a distribution for statistical analysis (NMFS 2013a). Instead, agencies use a fault tree model to represent expected spill frequency and severity of spills in the Arctic. Table 40 shows the assumptions the Bureau of Ocean Energy Management (BOEM) presented regarding the size and frequency of spills in the Beaufort and Chukchi Seas Planning Area in its final programmatic EIS for the Outer Continental Shelf oil and gas leasing program for 2012 to 2017 (BOEM 2012).

Table 40. Oil spill assumptions for the Beaufort and Chukchi Seas Planning Areas, 2012 to 2017

Spill Type	Assumed Spill Volume (barrels)	Assumed Number of Spill Events	Maximum Volume of Assumed Spill Events (barrels)
Small	≥ 1 to < 50	50 to 90	9,310
	≥ 50 to < 1,000	10 to 35	34,965
Large	≥ 1,000	-	-
Pipeline	1,700	1 to 2	3,400
Platform	5,100	1	5,100
Total			52,775
Table adapted from BOEM (2012)			

Increased oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic

waste (Hossain et al. 2014; Laidre et al. 2015; Simmonds and Elliott 2009). More information about spills in this region can be found in the *Pollutants and Contaminants* section (Section 5.7).

5.3.2 Cook Inlet

Cook Inlet is estimated to have 500 million barrels of oil and over 19 trillion cubic feet of natural gas that are undiscovered and technically recoverable (Wiggin 2017). Schenk et al. (2015) determined that there may also be unconventional oil and gas accumulations in Cook Inlet of up to 637 billion cubic feet of gas and 9 million barrels of natural gas liquids. Unconventional oil and gas accumulations: (1) have Estimated Ultimate Recoveries generally lower than conventional wells, (2) have low permeability and porosity, (3) require artificial stimulation for primary production, most commonly by hydraulic fracturing, (4) have only local to no migration of hydrocarbons (source rocks are reservoirs or in close proximity to reservoirs), (5) have no well-defined trap or seal, (6) have variable water production, (7) are generally not buoyant upon water, (8) have few truly dry holes, (9) have abnormal pressures, and (10) are regional in extent.

Lease sales for oil and gas development in Cook Inlet began in 1959 (Alaska Department of Natural Resources 2014). Prior to the lease sales, there were attempts at oil exploration along the west side of Cook Inlet. By the late 1960s, 14 offshore oil production facilities were installed in upper Cook Inlet, indicating that most of the Cook Inlet platforms and much of the associated infrastructure is over 50 years old. Today, there are 17 offshore oil and gas platforms in Cook Inlet. Figure 63 shows the ongoing oil and gas activities in state waters as of May 2019. In Cook Inlet, there is a total 211 active oil and gas leases encompassing approximately 450,412 acres of State leased land of which 311,265 acres are offshore (Alaska Department of Natural Resources 2020)(Figure 64).

In 2017, BOEM held Lease Sale #244 in Cook Inlet (Figure 65). Hilcorp was the only company responding, submitting bids on 14 of 224 tracts/Blocks offered; their successful bids encompass 31,005 acres. In 2019, NMFS issued Incidental Take Regulations for Hilcorp's oil and gas activities in Cook Inlet (84 FR 37442, July 31, 2019), including seismic surveys, and other exploration and development activities within these blocks (Figure 65). These seismic surveys are discussed further below.

5.3.2.1 Kenai LNG Plant

The existing Kenai LNG liquefaction and terminal complex adjacent to the coast of Cook Inlet began operating in 1969. Until 2012, it was the only facility in the United States authorized to export LNG produced from domestic natural gas. With LNG shipments from the terminal declining, the terminal's owner announced in mid-2017 that it would put the plant in long-term shutdown, and the terminal has remained in warm-idle since 2015. In early 2019, however, the owners informed NMFS of their intention to bring the plant back into operation within the next few years.

Based on existing active leases and estimates of undeveloped oil and gas resources, oil and gas development will likely continue in Cook Inlet; however, the overall effects on listed marine mammals are unknown (NMFS 2008a). The Cook Inlet Beluga Recovery Plan identified potential impacts from oil and gas development including increased noise from seismic activity,

vessel traffic, air traffic, and drilling; discharge of wastewater and drilling muds; habitat loss from the construction of oil and gas facilities; and contaminated food sources and/or injury resulting from an oil spill or natural gas blowout (NMFS 2016b).

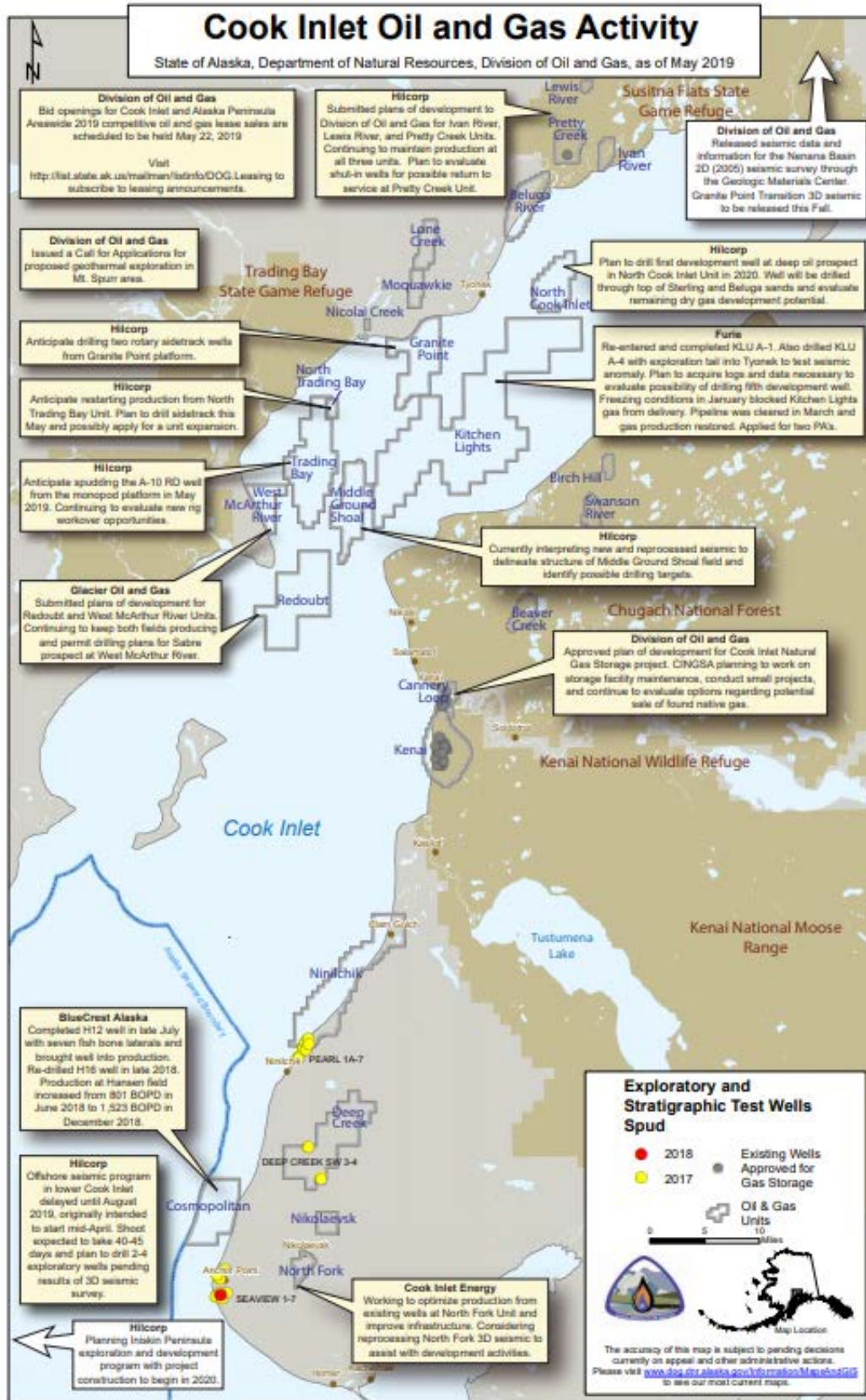


Figure 63. Oil and gas activity in Cook Inlet as of May 2019

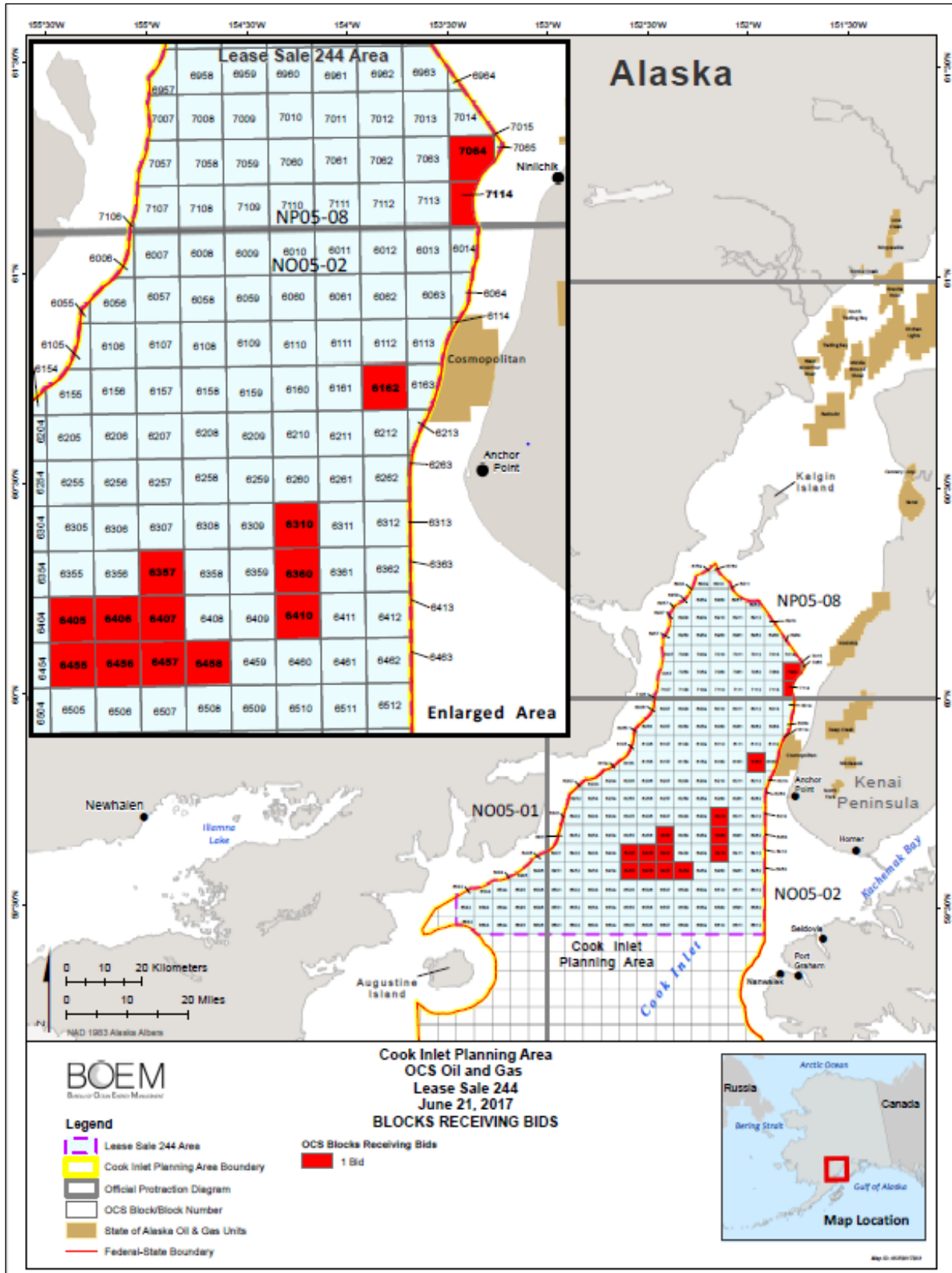


Figure 65. Lease Sale 244 blocks receiving bids

5.3.2.2 Underwater Installations

Pipelines are an essential part of oil and gas activities in Cook Inlet. There are numerous undersea pipelines in Cook Inlet, including oil and gas pipelines (Figure 66). Potential pipeline failures are associated with oil and gas development, with the associated possibility of oil spills, gas leaks, or other sources of marine petrochemical contamination.

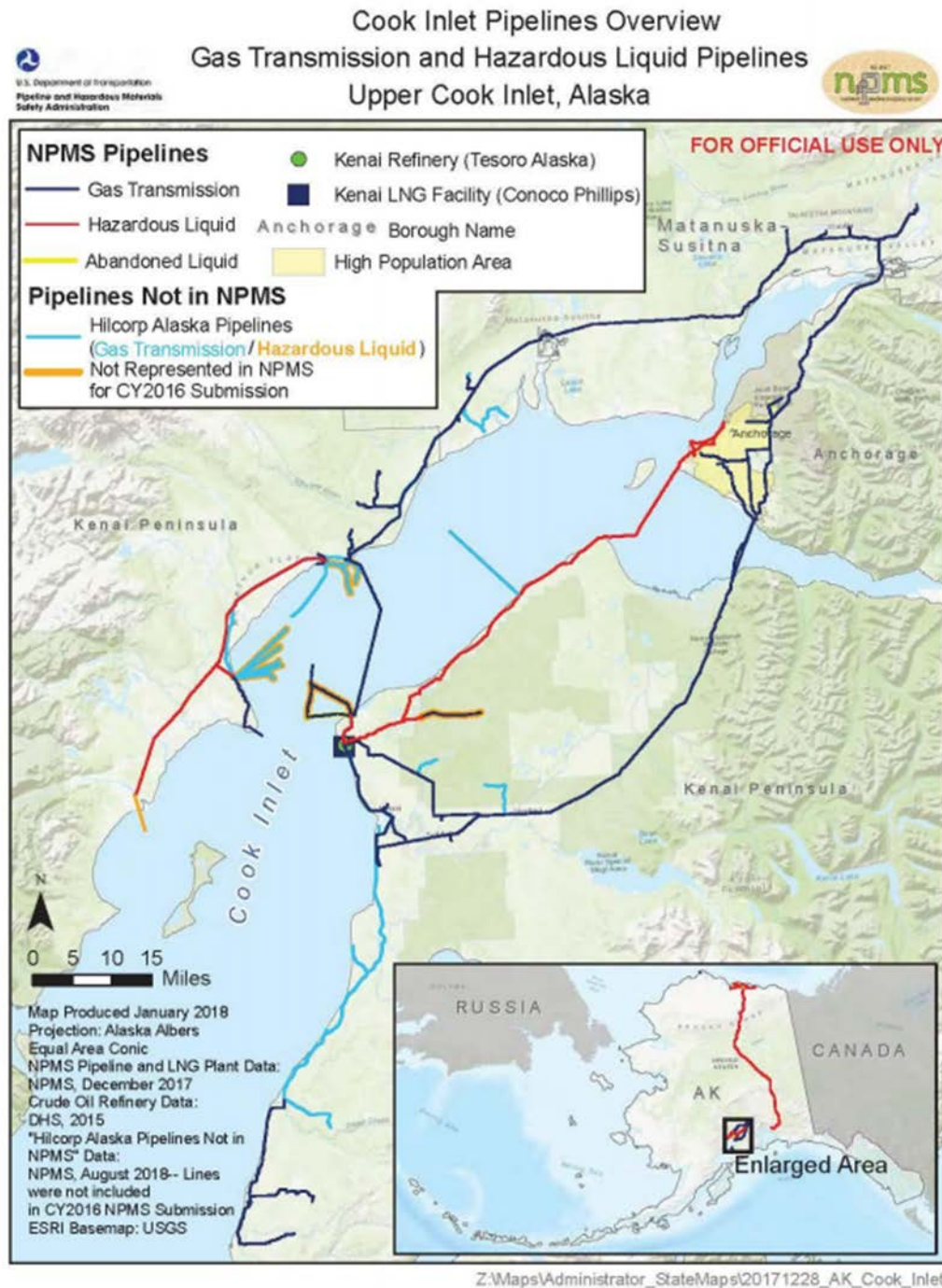


Figure 66. Existing pipelines in Cook Inlet

5.3.2.3 Trans-Foreland Pipeline

In 2014, the Trans-Foreland Pipeline Co. LLC (owned by Tesoro Alaska) received approval from state, Federal (including NMFS section 7 consultation AKR-2014-9394), and regional agencies to build the Trans-Foreland Pipeline, a 46.7-km (29-mi) long, 20.3-cm (8-in) diameter oil pipeline from the west side of Cook Inlet to the Tesoro refinery at Nikiski and the Nikiski-Kenai Pipeline company tank farm on the east side of Cook Inlet. The pipeline will be used by multiple oil producers in western Cook Inlet, to replace oil transport by tanker from the Drift River Tank farm. Horizontal directional drilling will be used at nearshore locations at the East and West Forelands to install the pipeline. This pipeline has not been constructed.

5.3.2.4 Hilcorp Cook Inlet Pipeline Cross Inlet Extension

In 2018, Hilcorp and Harvest Alaska LLC were issued an IHA associated with their plans to extend their existing undersea pipeline network to connect their Tyonek platform to the land-based Tyonek/Beluga, Alaska, pipeline at a point about 4 miles (6.4 km) north of the village of Tyonek. The IHA authorized Hilcorp to incidentally take, by Level B harassment, 40 Cook Inlet beluga whales, 6 Steller sea lions, and 5 humpback whales (NMFS 2018b). This project was completed in 2018 (Sitkiewicz et al. 2018).

5.4 Vessels

Ferries, cruise ships, tankers, ore carriers, commercial fishing vessels, and recreational vessels transit or operate within Alaska state and U.S. exclusive economic zone (EEZ) waters. Much of the vessel traffic in Alaskan waters is concentrated in coastal areas of southeastern and southcentral Alaska during the summer months, where recreational vessels, charter vessels, commercial whale watch vessels, tour boats, and cruise ships are prevalent. Traffic from large vessels is more likely to occur year-round statewide, in both near shore and offshore waters, and includes commercial fishing vessels, freighters/tankers, passenger ferries, etc. In general, there is less vessel traffic off western and northern Alaska compared to other parts of the state, although considerable traffic passes through the Aleutian Islands via the Great Circle Route. These trends are changing with climate change-driven decreases in sea ice in the Bering, Chukchi, and Beaufort seas (Neilson et al. 2012). Statewide, marine vessels are a known source of injury and mortality to marine mammals in Alaska, including some of the species considered in this Biological Opinion (Laist et al. 2001; Neilson et al. 2012). In addition to the potential for entanglement discussed in the sections above, vessel traffic may affect listed species through collisions (strikes) and increased ocean noise. Vessel traffic also has the potential to impact species via pollution from discharges and spills, and behavioral disruption (e.g., interference with foraging or migration, disturbance while resting or hauled-out).

5.4.1 Prudhoe Bay

The general seasonal pattern of vessel traffic in the Arctic is correlated with seasonal ice conditions, which results in the bulk of the traffic being concentrated within the months of July through October, and unaided navigation being limited to an even narrower time frame. However, this pattern appears to be rapidly changing, as ice-diminished conditions become more extensive during the summer months.

The number of unique vessels tracked via automated identification system (AIS) in U.S. waters north of the Pribilof Islands increased from 120 in 2008 to 250 in 2012, an increase of 108 percent (ICCT 2015). This includes only the northern Bering Sea, the Bering Strait, Chukchi Sea and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015).

However, the number of vessels identified in this region in 2012 likely also reflects traffic associated with the offshore exploratory drilling program that was conducted by Shell on the OCS of the Chukchi Sea that year. A comparison of the geographic distribution of vessel track lines between 2011 and 2012 provides some insight into the changes in vessel traffic patterns that may occur as a result of such activities (Figure 67). Overall, in 2012 there was a shift toward more offshore traffic and there were also noticeable localized changes in vessel traffic concentration near Prudhoe Bay and in the vicinity of the drilling project in the Chukchi Sea (ICCT 2015).

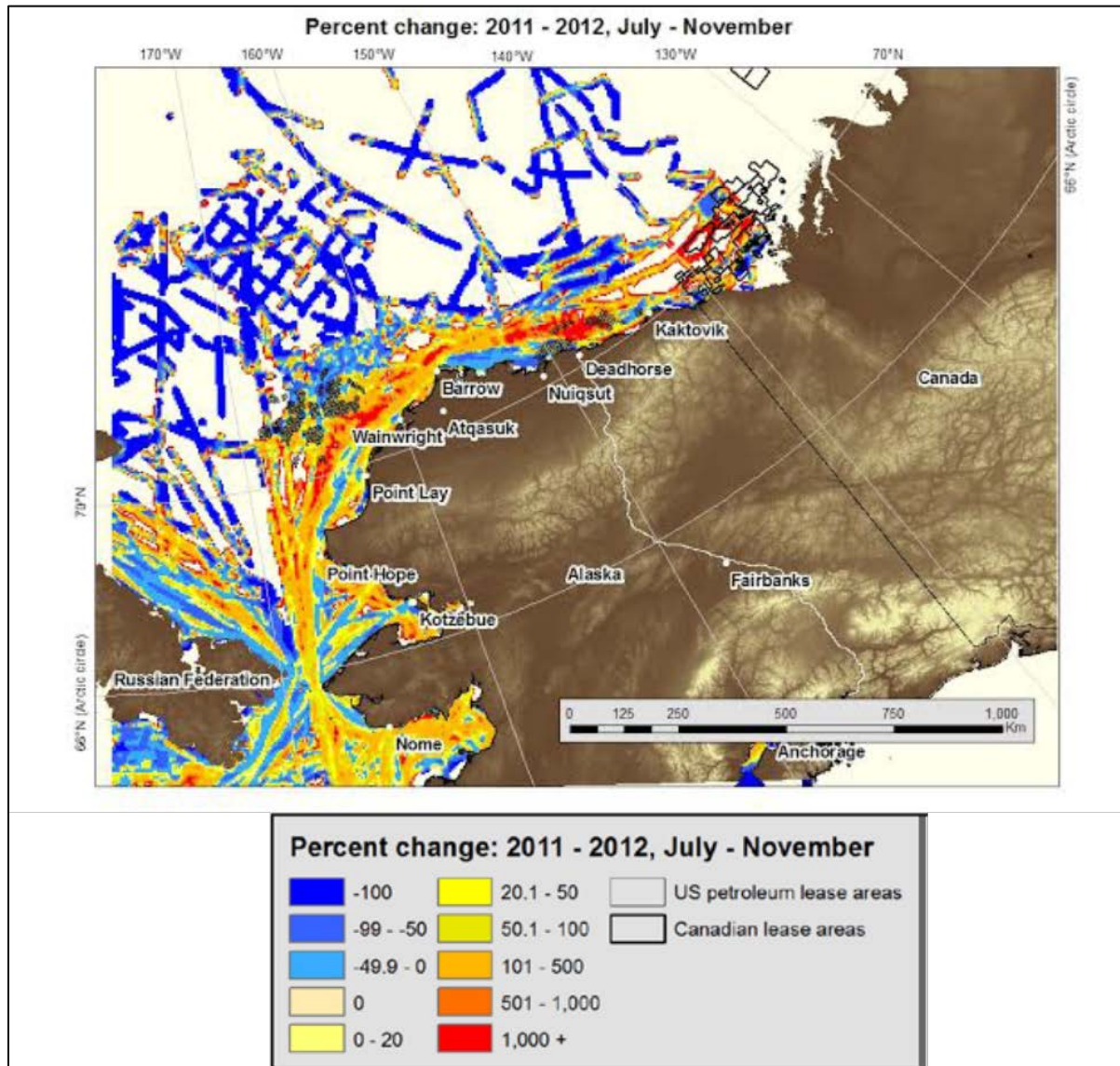


Figure 67. Percent difference in vessel activity between 2011 and 2012 using 5-km grid cells (ICCT 2015).

Surface air temperatures in the Arctic Region are increasing at double the rate of the global average (Adams and Silber 2017). Continued expansion of the duration and extent of seasonal ice-free waters in the Chukchi and Beaufort Seas is anticipated over the coming decades, resulting in increased vessel traffic. However, sea ice is still prevalent for many months of the year, especially in the Beaufort where over 75 percent of the water surface area was covered by sea ice for nine months in 2015, resulting in only 483 vessel transits. However, as seasonal ice-free waters expand, the international commercial transport of goods and people in the area is projected to increase 100-500 percent in some Arctic areas by 2025 (Adams and Silber 2017).

5.4.1.1 Vessel Noise

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the oceans (Hildebrand 2009; NRC 2003; Southall 2005). The types of vessels operating in the Beaufort Sea typically include barges, skiffs with outboard motors, icebreakers, scientific research vessels, and vessels associated with oil and gas exploration, development, and production. The primary underwater noise associated with vessel operations is the continuous noise produced from propellers and other on-board equipment. Cavitation noise is expected to dominate vessel acoustic output when tugs are pushing or towing barges or other vessels. Other noise sources include onboard diesel generators and the main engine, but both are subordinate to propeller harmonics (Gray and Greeley 1980). Shipping sounds are often at source levels of 150 to 190 dB re 1 μ Pa at 1 m (BOEM 2011) with frequencies of 20 to 300 Hz (Greene and Moore 1995). Sound produced by smaller boats is typically at a higher frequency, around 300 Hz (Greene and Moore 1995). In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background-sound levels (Greene and Moore 1995). Noise from icebreakers comes from the ice physically breaking, the propeller cavitation of the vessel, and the “bubbler systems” that blow compressed air under the hull which moves ice out of the way of the ship. Broadband source levels for icebreaking operations are typically between 177 and 198 dB re 1 μ Pa at 1m (Austin et al. 2015; Greene and Moore 1995); however, they can be extremely variable mainly due to the varying thickness of ice that is being broken and the resulting horsepower required to break the ice.

5.4.1.2 Vessel Strikes

There has been one reported vessel strike of a bowhead whale from Utqiagvik in 2015 (NMFS unpublished data). Increased vessel traffic resulting from a reduction in sea ice in the Arctic may lead to more vessel strike incidents in the future. To date, no bearded or ringed seal carcasses have been found with propeller marks.

5.4.2 Marine Transit Route

The Great Circle Route between western North America and East Asia intersects the Aleutian Island chain. Approximately two thousand (1,961) large vessels (300 gross tonnage (GT) or greater) made 4,615 transits through Unimak Pass in 2012 (Figure 68). Most of the ships recorded through Unimak Pass were non-tank vessels: 60 percent of the individual vessels recorded were bulkers, 24 percent container ships, and 13 percent other non-tank vessels. Fifty-two vessels, or 3 percent of the total individual vessels recorded, were tankers. Many more vessels likely traveled through the EEZ south of the Aleutian Islands (Nuka Research and Planning Group 2015a).

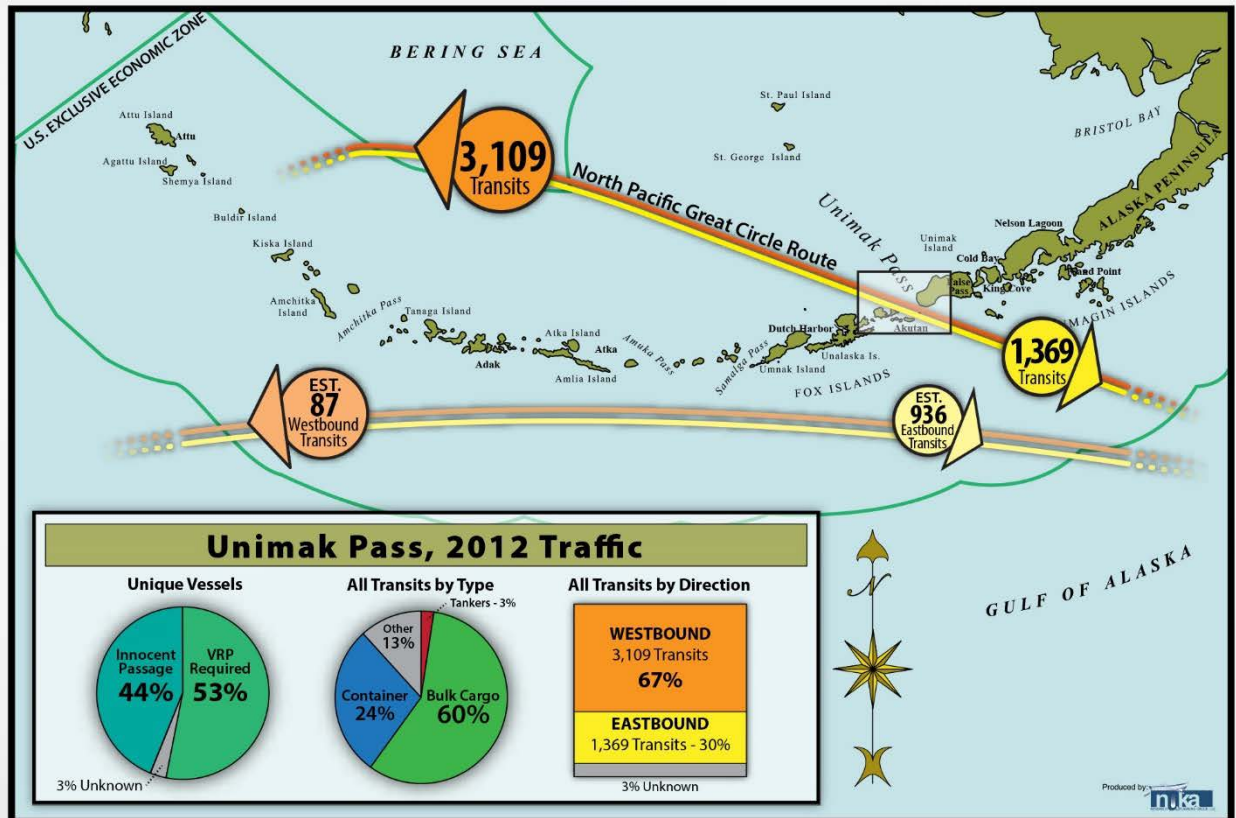


Figure 68. Summary of Unimak Pass traffic recorded in 2012, including percentage of vessels in innocent passage and by vessel type; also includes roughly estimated transits south of the island chain based on number of vessels going through Unimak Pass (Nuka Research and Planning Group 2015).

Commercial fishing vessels account for the highest number of transits and the most operational hours in a 2015 Bering Sea Vessel Analysis prepared by Nuka Research. These vessels operate in the southern Bering Sea year-round, and deliver fish to processing plants in coastal communities. Container ships and refrigerated cargo ships transfer the processed seafood to global markets (Nuka Research and Planning Group 2016). Tankers, general cargo ships, and barges move throughout the eastern Bering Sea serving coastal and inland communities. Vessels also support industrial activities and resource extraction in the region, or move goods or materials through the area to European, Asian, and other North American ports. Research vessels, U.S. Coast Guard and other government vessels, recreational vessels, and, more frequently, cruise ships operate here as well. The number of Bering Strait transits doubled from 2008 to 2015, and vessel traffic is expected to increase through the Bering Strait as Arctic sea ice retreats and both trans-Arctic shipping and the extraction of resources from Arctic countries grows (Nuka Research and Planning Group 2016).

5.4.2.1 Vessel Noise

See 'Vessel Noise' subsection above for Prudhoe Bay. The environmental baseline is similar along the marine transit route.

5.4.2.2 Vessel Strikes

From 1978-2012, there were at least 108 recorded whale-vessel collisions in Alaska (Neilson et al. 2012). Among larger whales, humpback whales are the most frequent victims of ship strikes in Alaska, accounting for 86 percent of all reported collisions. However, the majority of reported vessel strikes have occurred in Southeast Alaska (Neilson et al. 2012), with 4 reported strikes of either humpback or fin whales occurring in the GOA portion of the marine transit area from 2012 (NMFS unpublished data).

5.4.3 Cook Inlet

Cook Inlet is a regional hub of marine transportation throughout the year, and is used by various classes of vessels, including containerships, bulk cargo freighters, tankers, commercial and sport-fishing vessels, and recreational vessels. Vessel traffic density in Cook Inlet is concentrated along the eastern margin of the Inlet between the southern end of the Kenai Peninsula and north to Anchorage (Figure 69). Oil produced on the western side of Cook Inlet is transported by tankers to the refineries on the east side.

Shipping and transportation may affect Cook Inlet beluga habitat through the effects of noise, physical disturbance, and discharge (accidental and illegal) of oil, fuel, or other toxic substances carried by ships. The physical disturbance and noise associated with shipping and transportation activities could displace beluga prey species from preferred habitat areas that contain the features essential for this species, or that alter the quantity and/or quality of these essential features (NMFS 2016b). In the event of an oil spill, shallow water habitats could become oiled, and the quantity and/or quality of primary prey resources could be adversely affected. Vessel traffic and tourism encroachment in critical habitat areas could disturb and displace Cook Inlet belugas and/or their prey species, resulting in reduced conservation value of the critical habitat.

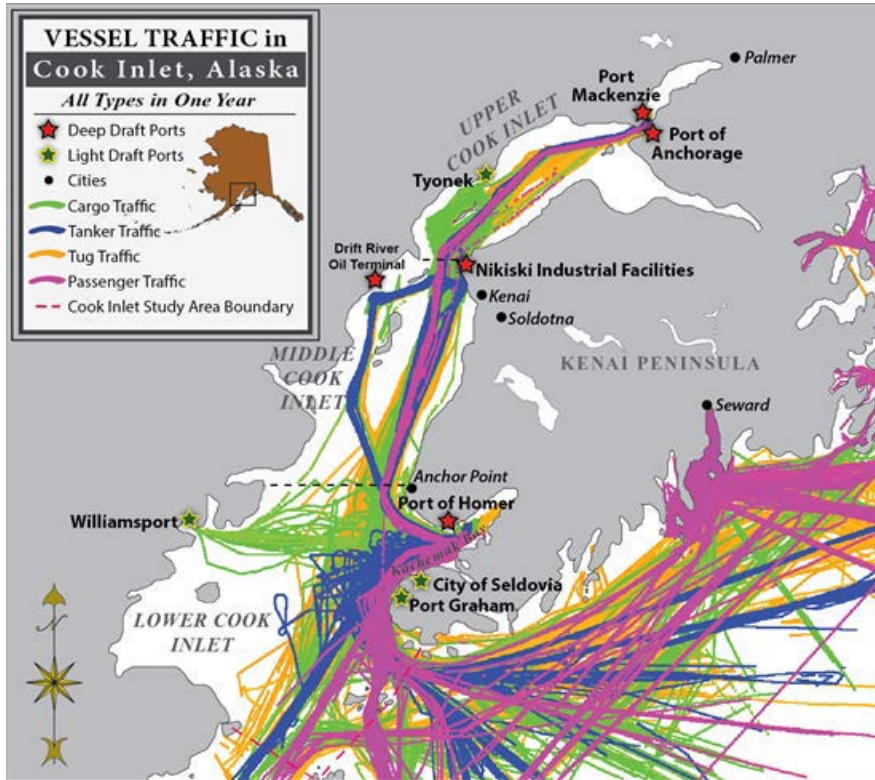


Figure 69. Summary of Cook Inlet vessel traffic by vessel type (Cape International, Inc. 2012, (BOEM 2017c)). Only vessels more than 300 gross tons are shown.

5.4.3.1 Vessel Noise

Two of the vessels that make regular calls to the POA, the *Midnight Sun* and the *North Star*, are 53,000-horsepower, 839-foot cargo ships that pass through Cook Inlet at 15 to 20 kn four times per week, equaling 208 transits per year (Eley 2012). Blackwell and Greene (2003) observed that beluga whales “did not seem bothered” when the whales were travelling slowly within a few meters of the hull and stern of the moored cargo-freight ship *Northern Lights* in the Anchorage harbor area. They speculated that in areas where belugas are subjected to a lot of (perennial) boat traffic, they may habituate and become tolerant of the vessels. However, noises from ships and other activities in Cook Inlet area may cause a decrease or cessation of beluga vocalizations, or mask their vocalizations (Castellote et al. 2015).

Blackwell and Greene (2003) recorded underwater noise produced by both large and small vessels near the POA. The tugboat *Leo* produced the highest broadband levels of 149 dB re: 1 μ Pa at a distance of approximately 100 m (328 ft), while the docked *Northern Lights* (cargo freight ship) produced the lowest broadband levels of 126 dB re: 1 μ Pa at 100 to 400 m (328-1,312 ft). Continuous noise from ships generally exceeds 120 dB re 1 μ Pa_{RMS} to distances between 500 and 2,000 m (1,640 and 6,562 ft), although noise effects are short term as the vessels are continuously moving (BOEM 2017a).

Humpback and fin whales may exhibit varying reactions to the presence of vessels, ranging from attraction (especially if animals are habituated to vessels as a source of food) to avoidance. Some

vessels, such as tugs towing barges or oil rigs, can produce sound capable of harassing marine mammals located over 2 km from the source (Jacobs Engineering 2017).

5.4.3.2 Vessel Strikes

Cook Inlet beluga whales may be susceptible to vessel strike mortality. To date, however, only one whale death, in October 2007, has been attributed to a potential vessel strike based on bruising consistent with blunt force injuries (NMFS unpublished data). Beluga whales may be especially susceptible to strikes from commercial and recreational fishing vessels (as opposed to cargo ships, oil tankers, and barges) since both belugas and fishing activities occur where salmon and eulachon congregate. A number of beluga whales have been photographed with propeller scars (McGuire et al. 2014), suggesting that small vessel strikes are not rare, but such strikes are often survivable. Small boats are able to quickly approach and disturb these whales in their preferred shallow coastal habitat.

There have been five documented cetacean vessel collisions in Cook Inlet since 2001; one humpback whale, one fin whale, and one unidentified large cetacean. In 2001, a humpback whale was discovered on the bulbous bow of a 710 ft container ship as it docked in the Port of Anchorage. It is unknown where the vessel may have collided with the whale. In 2005, a 28 ft charter boat hit an unidentified large cetacean. In 2015, one dead fin whale came into the Port of Anchorage on the bulbous bow of a ship traveling from Seattle, but it was unknown where the strike occurred (NMFS AKR, unpub. data).

5.5 Ambient and Anthropogenic Noise

ESA-listed species in the action area are exposed to several sources of ambient (natural) and anthropogenic (human-caused) noise. The combination of anthropogenic and ambient noises contributes to the total noise at any one place and time. Ambient sources of underwater noise include sea ice, wind, waves, precipitation, and biological noise from marine mammals, fishes, and crustaceans. Other anthropogenic sources of underwater noise of concern to listed species in Alaska include in-water construction activities such as drilling, dredging, and pile driving; oil, gas, and mineral exploration and extraction; Navy sonar and other military activities; geophysical seismic surveys; and ocean research activities. Levels of anthropogenic sound can vary dramatically depending on the season, type of activity, and local conditions. Noise impacts to listed marine mammal species state-wide from many of these activities are mitigated through ESA Section 7 consultations.

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. As described in greater detail later in this opinion, noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress. Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury, and, in some cases, may result in behaviors that ultimately lead to death. The severity of these impacts can vary greatly between minor impacts that have no real cost to the animal, to more severe impacts that may have lasting consequences.

Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). The presence and movements of ships in the vicinity of seals can affect their normal behavior (Jansen et al. 2010) and may cause them to abandon their preferred breeding habitats in areas with high traffic (Allen 1984; Edrén et al. 2010; Henry and Hammill 2001; London et al. 2012; Sullivan 1980). Clark et al. (2009) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate (i.e., masking). Some research (McDonald et al. 2006; Parks 2003; Parks 2009) suggests marine mammals compensate for masking by changing the frequency, source level, redundancy, and timing of their calls. However, the long-term implications of these adjustments, if any, are currently unknown.

Because noise is a primary source of disturbance to marine mammals, and the category of disturbance most focused on in Incidental Harassment Authorizations and Letters of Authorization, this opinion considers it as a separate category of the Environmental Baseline.

5.5.1 Prudhoe Bay and Marine Transit Route

5.5.1.1 Ambient Noise

The presence of ice can contribute significantly to ambient sound levels and affects sound propagation. While sea ice can produce substantial amounts of ambient sounds, it also can function to dampen or heighten ambient sound. Smooth annual ice can enhance sound propagation compared to open water conditions (Richardson et al. 1995). However, with increased cracking, ridging, and other forms of sub-surface deformation, transmission losses generally become higher compared to open water (Richardson et al. 1995, Blackwell and Greene 2001). Urick (1983) discussed variability of ambient noise in water, including under Arctic ice; he stated that “the ambient background depends upon the nature of ice, whether continuous, broken, moving or shore-fast, the temperature of air, and the speed of the wind.” Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. The spectrum of cracking ice sounds typically displays a broad range from 100 Hz to 1 kHz, and the spectrum level has been observed to vary as much as 15 dB re 1 μ Pa at 1 m within 24 hours due to diurnal variability in air temperatures (BOEM 2011). Data are limited, but in at least one instance it has been shown that ice-deformation sounds produced frequencies of 4 to 200 Hz (Greene 1981).

During the open-water season in the Arctic, wind and waves are important sources of ambient sound with levels tending to increase with increased wind and sea state, all other factors being equal (Richardson et al. 1995). Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz.

There are many marine mammals in the Arctic marine environment whose vocalizations contribute to ambient sound including bowhead whales, gray whales, beluga whales, walrus, ringed seals, bearded seals, and spotted seals. Walrus, seals, and seabirds all produce sound that can be heard in air as well. Ringed seal calls have a source level of 95 to 130 dB re 1 μ Pa at 1 m, with the dominant frequency under 5 kHz (Cummings et al. 1986; Thomson and Richardson 1995).

Ambient noise levels recorded during the open-water season (July 6 through September 22) in Foggy Island Bay varied from approximately 88 to 103 dB re μ Pa broadband (Aerts et al. 2008). These ambient noise levels may have been influenced by other vessel activities occurring nearby (Aerts et al. 2008). Broadband background sound levels recorded in the water under the ice at 9.4 km (5.8 mi) from Northstar Island were 77 dB re μ Pa and 76 dB re μ Pa in 2001 and 2002, respectively (Blackwell et al. 2004b).

5.5.1.2 Oil & Gas Exploration, Drilling, and Production Noise

NMFS has conducted numerous ESA section 7 consultations related to oil and gas activities in the Beaufort Sea. Many of the consultations have authorized the take (by harassment) of bowhead whales and ringed and bearded seals (as well as non ESA-listed marine mammals) from sounds produced during geophysical (including seismic) surveys and other exploration and development activities.

In 2013, NMFS completed an incremental step consultation with BOEM and Bureau of Safety and Environmental Enforcement (BSEE) on the effects of the authorization of oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi Seas over a 14-year period, from March 2013 to March 2027 (i.e., the Arctic Regional Biological Opinion; (NMFS 2013b)). The incidental take statement issued with the biological opinion for the 14-year period allows for takes (by harassment) from sounds associated with high-resolution, deep penetration, and in-ice deep penetration seismic surveys of 87,878 bowhead whales, 896 fin whales, 1,400 humpback whales, 91,616 bearded seals, and 506,898 ringed seals. Take will be more accurately evaluated and authorized for project-specific consultations that fall under this over-arching consultation (i.e., stepwise consultations), and the cumulative take for all subsequent consultations will be tracked and tiered to these consultations.

In addition, NMFS completed an incremental step consultation with BOEM and BSEE in 2015 on the effects of oil and gas exploration activities for lease sale 193 in the Chukchi Sea, Alaska, over a nine-year period, from June 2015 to June 2024 (NMFS 2015a). The incidental take statement issued with the biological opinion allows for takes (by harassment) from sounds associated with seismic, geohazard, and geotechnical surveys, and exploratory drilling of 8,434 bowhead whales, 133 fin whales, 133 humpback whales, 1,045,985 ringed seals, and 832,013 bearded seals.

In 2014, NMFS Alaska Region conducted three internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to 3D ocean bottom sensor seismic and shallow geohazard surveys in Prudhoe Bay, Foggy Island Bay, and the Colville River Delta, in the Beaufort Sea, Alaska, during the 2014 open-water season (NMFS 2014a; NMFS 2014b; NMFS 2014c). These project-specific consultations were either directly or indirectly linked to the Arctic regional biological opinion. The incidental take statements issued with the three biological opinions allowed for takes (by harassment) of 138 bowhead whales, 744 bearded seals, and 427 ringed seals, total, as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μ Pa.

In 2015, NMFS Alaska Region conducted two internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to shallow geohazard and

3D ocean bottom node seismic surveys in the Beaufort Sea, Alaska, during the 2015 open-water season. These consultations were also either directly or indirectly linked to the Arctic regional biological opinion. The incidental take statements in the three biological opinions estimated 461 bowhead whales, 202 bearded seals, and 1,472 ringed seals, total, would be taken (by harassment) as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μ Parms and one bowhead whale, 10 bearded seals, and 20 ringed seals as a result of exposure to impulsive sounds at received levels at or above 180 dB re 1 μ Parms.

In 2015, NMFS Alaska Region conducted an internal consultation with NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to ice overflight and ice survey activities conducted by Shell Gulf of Mexico and Shell Offshore Inc., from May 2015 to April 2016 (NMFS 2015b). The incidental take statement issued with the biological opinion authorized takes (by harassment) of 793 ringed seals and 11 bearded seals as a result of exposure to visual and acoustic stimuli from aircraft.

The first stepwise (i.e., tiered) consultation under the lease sale 193 incremental step consultation was conducted in 2015. NMFS Alaska Region consulted with the NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to exploration drilling activities in the Chukchi Sea, Alaska, in 2015 (NMFS 2015a). The incidental take statement issued with the biological opinion allowed for takes (by harassment) of 1,083 bowhead whales, 14 fin whales, 14 humpback whales, 1,722 bearded seals, and 25,217 ringed seals as a result of exposure to continuous and impulsive sounds at received levels at or above 120 dB re 1 μ Parms and 160 dB re 1 μ Parms, respectively.

There were no consultations for oil and gas activities completed with the NMFS Permits Division in 2016 and 2017.

In 2018, NMFS Alaska Region completed a consultation with BOEM, BSEE, EPA, and USACE for oil and gas exploration activities for the Liberty Project taking place from December 2020 to November 2045 (NMFS 2018a). In 2019, the NMFS Alaska Region reinitiated consultation with BOEM, BSEE, EPA, and USACE for the Liberty Project and conducted a consultation with the NMFS Permits Division on the issuance of a letter of authorization (LOA) to take marine mammals incidental to oil and gas exploration activities for the Liberty Oil and Gas Development and Production Activities. The incidental take statement issued with the biological opinion allowed for takes of ringed seals: 831 by Level B harassment due to noise and physical presence, 8 by Level A harassment due to noise, and 10 by mortality. The incidental take statement also allowed for the following take: for bowhead whales, 120 by Level B harassment and 4 by Level A harassment and for bearded seals, 130 by Level B harassment due to noise and physical presence and 4 by Level A harassment.

In 2019, NMFS Alaska Region completed a programmatic consultation with the Bureau of Land Management for the implementation of the oil and gas lease sales for the Arctic National Wildlife Refuge coastal plain. The consultation was based on the most likely scenario for oil exploration, development, production, and abandonment. An incidental take statement is not issued for programmatic consultations, however, if blocks are leased within the Arctic National Wildlife Refuge, consultations will be required for future activities that may affect listed species on these leased blocks.

5.5.1.3 Seismic Activity Noise

Seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical two-dimensional/three-dimensional (2D/3D) seismic survey with multiple guns emits sound at frequencies of about 10 Hz to 3 kHz (Austin et al. 2015). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for several kilometers (Greene and Moore 1995; Greene and Richardson 1988). Analysis of sound associated with seismic operations in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1,300 km (808 mi) (Richardson 1998; Richardson 1999; Thode et al. 2010). Because the Chukchi Sea continental shelf has a highly uniform depth of 30 to 50 m (98 to 164 ft), it strongly supports sound propagation in the 50 to 500 Hz frequency band (Funk et al. 2008).

Several of the section 7 consultations discussed in the previous subsection include take (by harassment) of marine mammals from noise produced through seismic activity, among other oil and gas-related activities.

5.5.2 Cook Inlet

5.5.2.1 Ambient Noise

Natural physical underwater noise in Cook Inlet originates from wind, waves at the surface, currents, earthquakes, ice movement, tidal currents, and atmospheric noise (Richardson et al. 1995). Tidal influences in Cook Inlet are a predominant contributor of physical noise to the acoustic environment (BOEM 2016a; Burgess 2014).

Biological noise includes sounds produced by marine mammals (particularly whales and dolphins, but also pinnipeds), fish (Maruska and Mensinger 2009), and invertebrates (Chitre et al. 2005). Much of upper Cook Inlet is a poor acoustic propagation environment due to shallow depths and sand and mud bottoms. In general, ambient and background noise levels within the action area in Cook Inlet are assumed to be less than 120 dB whenever conditions are calm, and exceeding 120 dB during environmental events such as high winds and peak tidal fluctuations (Blackwell and Greene 2003; Illingworth & Rodkin 2014).

5.5.2.2 Oil & Gas Exploration, Drilling, and Production Noise

The greatest noise levels from drilling platforms originate from operating noises from the oil platform, not from the noise generated by drilling, with frequencies generally below 10 kHz. In general, noise from the platform itself is thought to be very weak because of the small surface area (the four legs) in contact with the water (Richardson et al. 1995) and that the majority of the machinery is on the deck of the platform, which is above the water surface. However, noise carried down the legs of the platform likely contributed to the higher noise levels than anticipated (Blackwell and Greene 2003). Blackwell and Greene (2003) recorded underwater noise produced at Phillips A oil platform (now the Tyonek platform) at distances ranging from 0.3 to 19 km (0.2 to 12 mi) from the source. The highest recorded sound level was 119 dB at a distance of 1.2 km (0.75 mi). Noise between two and 10 kHz was measured as high as 85 dB as far out as 19 km from the source. This noise is audible to beluga, humpback, and fin whales.

AK LNG (2016)

In 2016, ExxonMobil Alaska LNG LCC (EMALL) conducted geophysical and geotechnical surveys in Upper Cook Inlet, including within the Susitna Delta Exclusion Zone (SUDEX), under the terms of an IHA and biological opinion issued by NMFS. Operations involving G&G equipment did not occur within the SUDEX between 15 April and 15 October, 2016. PSOs monitored for all marine mammals prior to and during all vessel movements when vessels were under power within the SUDEX. A total of 3 marine mammal sightings consisting of 5 estimated individuals were seen within the SUDEX. These included 2 sightings of beluga whales (4 individuals), and 1 sighting of a single harbor seal. The two beluga whale sightings occurred greater than 700 m from the vessel outside of the harassment zone for that project activity (vessel movement). All marine mammal sightings in the SUDEX occurred during non-operational periods (i.e., when no vibracore operations were occurring).

Furie Exploration Drilling (2017)

Within the Kitchen Lights Unit (KLU) of Cook Inlet, Furie intends to drill up to nine wells between 2017 and 2021. The KLU is an offshore lease area of 83,394 acres, north of the East Foreland and south of the village of Tyonek in Cook Inlet, Alaska.

The Furie KLU drilling have the potential to affect the endangered Cook Inlet beluga whale, the endangered Western North Pacific DPS humpback whale, the threatened Mexico DPS humpback whale, the endangered Western DPS Steller sea lion, the endangered fin whale, and designated critical habitat for Cook Inlet beluga whales and Steller sea lions.

Actions associated with Furie's proposed activity include transport of a jack-up rig, the *Randolph Yost*, by up to three tugs to the drilling sites, high-resolution geophysical surveys, pile driving at each drilling location, drilling operations, vessel and air traffic associated with rig operations, fuel storage, and well completion activities. NMFS completed consultation on this action in 2017 (NMFS 2017a). No take was anticipated or authorized for 2017 operations. However, subsequent activities will require MMPA authorization.

Hilcorp Oil and Gas

In addition to the seismic survey discussed below, the Hilcorp Incidental Take Regulations issued in 2019 included oil and gas exploration, development, production, and decommissioning activities in lower Cook Inlet, Alaska between June 1, 2019 and June 1, 2024. Hilcorp conducted a 3D seismic survey from September 10, 2019, to October 17, 2019 in lower Cook Inlet, and Hilcorp plans to conduct the exploratory drilling program April to October between 2020 and 2022. The exact start date of production is currently unknown and is dependent on the results of the seismic survey, geohazard survey, and scheduling availability of the drill rig. It is expected that each well will take approximately 40 to 60 days to drill and test. Beginning in spring 2020, Hilcorp plans to possibly drill two and as many as four exploratory wells, pending results of the 3D seismic survey in the lower Cook Inlet OCS leases. After testing, the wells may be plugged and abandoned.

5.5.2.3 Seismic Activity Noise

Cook Inlet has a long history of oil and gas activities including seismic exploration, geophysical and geological surveys, exploratory drilling, increased vessel and air traffic, and platform production operation. A seismic program occurred near Anchor Point, Alaska, in the fall of 2005. Geophysical seismic operations were conducted in Cook Inlet during 2007, near Tyonek, East and West Forelands, Anchor Point, and Clam Gulch. Additional small seismic surveys were conducted in Cook Inlet during 2012. From 2013 to 2015 approximately 3,367 km² (1,300 mi²) of 3D and 40,000 km (25,000 mi) of 2D seismic line surveys have been conducted in Cook Inlet (Figure 70). A large seismic program took place in 2013 and 2014; data were collected between Anchorage and Anchor Point. Another large seismic survey took place in 2015 and 2016 in Cook Inlet between Beluga, Alaska, and across Cook Inlet to Salamatof, Alaska, and along the eastern inlet between Kalifornsky, Alaska, and south to Anchor Point. More recently, Hilcorp conducted a 3D seismic survey in lower Cook Inlet in September 2019.

Seismic surveys use high energy, low frequency sound in short pulse durations to characterize subsurface geology (Richardson et al. 1995), often to determine the location of oil and gas reserves. Geophysical seismic activity has the potential to harass or harm marine mammals (Nowacek et al. 2015), including beluga whales.

In the past, large airgun arrays of greater than 3,000 in³ were used for seismic exploration in Cook Inlet; these can produce source noise levels exceeding 240 dB re 1 μ Pa rms. However, smaller arrays are now being used in Cook Inlet because of the generally shallow water environment and the increased use of ocean-bottom cable and ocean-bottom node technology (Rigzone 2012). Seismic surveys in Cook Inlet have recently used maximum airgun arrays of 1,760 and 2,400 in³ with source levels of about 237 dB re 1 μ Pa_{RMS}. Shallow water surveys have involved 440, 620, and 880 in³ arrays with source sound pressure levels less than 230 dB re 1 μ Pa_{RMS}. Measured radii to Level B (160 dB) harassment isopleths have ranged from 3 to 9.5 km (1.8-5.9 mi).

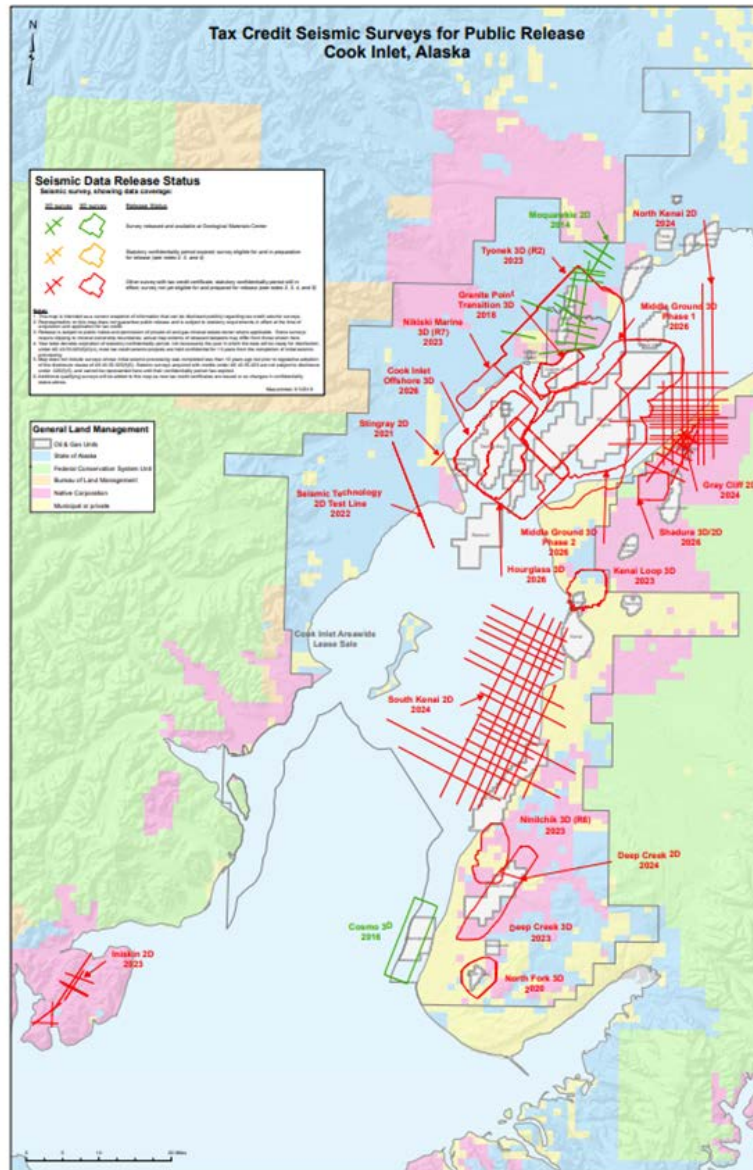


Figure 70. Seismic surveys in Cook Inlet. Dates indicate year technical data is scheduled for release.

Apache Alaska Corporation Seismic Exploration (2012-2014)

During over 1,800 hours of seismic activity in 2012, Apache Alaska Corporation (Apache) reported zero takes of either beluga whales or Steller sea lions; although some protected marine mammals were observed within zones ensounded to greater than 120 and 160 dB prior to powering down or shutting down of equipment. The company experienced five delays resulting from clearing the 160 dB disturbance zone, six shutdowns, one power-down, one shutdown followed by a power-down, and one speed and course alteration (Lomac-MacNair et al. 2013). In 2014, however, despite implementing a total of 13 shut-downs and 7 ramp-up delays for all marine mammals (non- and ESA-listed species), observers recorded a total of 29 takes (12

beluga whales, 6 harbor porpoise, 9 harbor seals, and 2 humpback whales) from noise exposures (25 at ≥ 160 dB_{RMS} and 4 at ≥ 180 dB_{RMS}) (Lomac-MacNair 2014). Also during Apache's 2014 operations, four groups of beluga whales occurred less than 500 m from the Apache source vessel during seismic operations (0.0014 groups per hour of effort x 3,029.2 total hours of observation effort) (Lomac-MacNair 2014). The report does not state whether seismic guns were firing at this time. If these close approaches by belugas occurred during operation of the 1,760 in³ airgun array that was being used, that would represent 4 groups of belugas (of unstated group size) subjected to Level A take (Level A take isopleth for 1,760 in³ array for cetaceans = 1,840 m).

NMFS is aware of at least one humpback whale having been observed and possibly taken in upper Cook Inlet (by harassment and/or injury) by Apache's seismic operations on April 25, 2014, by the M/V *Peregrine Falcon* operating a 1,760 in³ airgun array at full volume. The humpback whale was first observed 1.5 km (0.9 mi) from the sound source at a time when all whales within 1.84 km (1.1 mi) of the sound source would have been exposed to MMPA Level A take (sound impulses in excess of 180 dB). Although seismic operations were shut down immediately after observing this animal, the whale apparently was exposed to full volume seismic impulses during the time it transited from 1.84 km to 1.5 km (1.1 mi to 0.9 mi) from the sound source. Assuming seismic shots were fired at 15 second intervals and assuming the whale traveled directly towards the source at the average cruising speed of a humpback whale (4.0 km/hour [2.5 mi/hour]) (Noad and Cato 2007), then this whale would have been exposed to at least 19 impulses exceeding the 180 dB threshold for Level A take while it was within the exclusion zone prior to shut-down.

SAExploration 3D Seismic Exploration (2015)

Seismic operations by SAExploration (SAE) took place in upper Cook Inlet beginning on 15 May 2015, and continued until 27 September 2015. Eight vessels operated during the surveys including two seismic source vessels, the M/V *Arctic Wolf* and M/V *Peregrine Falcon*, and one mitigation vessel, the M/V *Westward Wind*. Seven PSOs were stationed on the source and mitigation vessels, including two on each source vessel, and three on the mitigation vessel. PSOs monitored from the vessels during all daylight seismic operations and most daylight non-seismic operations.

One trained passive acoustic monitoring operator was stationed on a vessel to conduct monitoring during nighttime hours using a dipping or over-the-side hydrophone.

A total of 932 sightings (i.e., groups) of approximately 1,878 individual marine mammals were visually observed from 15 May through 27 September 2015. Harbor seals were the most commonly observed species with 823 sightings (~ 1,680 individuals), followed by harbor porpoises with 52 sightings (~65 individuals), sea otters with 29 sightings (~79 individuals), and beluga whales with eight sightings (~33 individuals). Large whale sightings consisted of three humpback whale sightings (~3 individuals), one minke whale sighting (1 individual), and one unidentified large cetacean. Other observations include one killer whale sighting (~2 individuals), one Dall's porpoise, four Steller sea lions, two unidentified dolphins/porpoise, five unidentified pinnipeds, and two unidentified marine mammals.

Passive acoustic monitoring occurred from 1 July through 27 September and yielded a total of 15 marine mammal acoustic detections including two beluga whale and 13 unidentified porpoise. Nine detections occurred during seismic activity and six occurred during non-seismic activity. There were no acoustic detections of baleen whales or pinnipeds.

Of these visual observations and acoustic detections, 207 marine mammals were confirmed within both the Level A (190 and 180 dB) and B (160 dB) exposures zones, resulting in 194 Level B and 13 Level A exposures (Kendall et al. 2015).

Species composition of animals known to occur within the Level B exposure zone, through visual observations, included harbor porpoises, a Steller sea lion, harbor seals, and an unidentified large cetacean. An additional two beluga whales and one unidentified porpoise were acoustically detected within the Level B exposure zone. Marine mammals observed within the Level A exposure zone included harbor porpoises, a Steller sea lion, and harbor seals.

Additional takes were avoided due to the 70 sightings that occurred during clearing the disturbance zone, 14 sightings that occurred during ramp-up, and the 18 shut downs that were implemented because of these sightings. No power downs or speed/course alterations were performed due to marine mammal sightings (Kendall et al. 2015).

Hilcorp 3D Seismic – Lower Cook Inlet, Outer Continental Shelf (2019)

Hilcorp conducted a 3D seismic survey from September 10-October 17, 2019 in Lower Cook Inlet, comprised of approximately 790 square kilometers (km²) over 8 Outer Continental Shelf (OCS) lease blocks (Figure 64). The seismic survey included four vessels: one source, two support, and one for marine mammal mitigation. PSOs were stationed onboard the source (*Polarcus Alima*) and mitigation (*R/V Q105*) vessels. Daily aerial surveys were conducted with a fixed-wing, high-wing P68C aircraft based in Homer, Alaska, that flew east-west transects over the seismic activity area. The sightings during the seismic project are presented in Table 41.

Table 41. Sightings of ESA-listed marine mammals during Hilcorp’s 2019 seismic surveys in Lower Cook Inlet

ESA-listed species	# of sightings ^a	Estimated # of individuals ^b	Project Level B exposures ^d
Fin whale	8	23	10.9
Humpback whale ^c	14	38	31.5
Beluga whale	2	2	0
Steller sea lion	5	5	4.9

^aOne sighting equals one group.

^bTotals do not include re-sightings.

^cIncludes both Western North Pacific and Mexico DPS.

^dBased on actual take + estimated take.

5.5.2.4 Construction and Dredging Noise

Pile driving and dredging are the primary sources of construction noise in Cook Inlet. The Port of Alaska is dredged annually and construction noise from pile driving is the primary noise source from the proposed activities in this opinion.

Port MacKenzie, located just two miles away across Cook Inlet, has also undergone recent renovations and multiple emergency repairs requiring pile driving, including removal and installation of sheet piles (NMFS 2017b).

The majority of such construction activities have taken place near Anchorage. Therefore, most of the studies documenting construction noise in Cook Inlet have occurred within the action area. These studies have focused almost exclusively on pile driving because of the concerns of potential harassment to beluga whales from this activity. As a result there is very little to no documentation of noise levels from other construction activity in Cook Inlet. Only a few studies have recorded dredging noise near the POA (URS 2007; USACE-DOER 2001).

Small and/or private docks also may utilize pile driving as a part of their expansions or repairs (e.g., the Offshore System Kenai dock in Nikiski was approved to be upgraded and expanded in 2012). Repair of sewage lines and construction of dock facilities occurred during the time that this project took place; activities that introduced noise to the marine environment. However, there was no documentation of noise levels from this repair work.

5.5.3 Aircraft Noise

The noise and visual presence of aircraft can result in behavioral changes in whales such as diving, altering course, vigorous swimming, and breaching (Patenaude et al. 2002). The airspace above Cook Inlet experiences significant levels of aircraft traffic. Anchorage Ted Stevens International Airport is directly adjacent to lower Knik Arm and receives high volumes of commercial air traffic. It is also the second largest air cargo hub in the U.S. Joint Base Elmendorf Richardson also has a runway near and airspace directly over Knik Arm. Lake Hood in Anchorage is the world's largest and busiest seaplane base and the only seaplane base with primary airport status in the United States (Federal Aviation Administration 2016). Other small public runways are found at Birchwood, Goose Bay, Merrill Field, Girdwood, the Kenai Municipal Airport, Ninilchik, Homer, and Seldovia. Oil and gas development projects often involve helicopters and fixed-winged aircraft, and aircraft are used for surveys of natural resources including Cook Inlet beluga whales. Airborne sounds do not transfer well to water because much of the sound is attenuated at the surface or is reflected where angles of incidence are greater than 13°; however, loud aircraft noise can be heard underwater when aircraft are within or near the 13° overhead cone and surface conditions are calm (Richardson et al. 1995).

Richardson et al. (1995) observed that beluga whales in the Beaufort Sea will dive or swim away when low-flying (500 m (1640 ft)) aircraft pass above them. Observers aboard Cook Inlet beluga whale survey aircraft flying at approximately 244 m (800 ft) report little or no change in swimming direction of the whales (Rugh et al. 2000). However, ground-based biologists note that Cook Inlet belugas often dive and remain submersed for longer than is typical when aircraft fly past at low altitudes or circle them (NMFS unpublished data). Individual responses of belugas

may vary, depending on previous experiences, beluga activity at the time of the noise, and noise characteristics.

5.5.4 Noise and Critical Habitat

Due to the industrial activity, development, and vessel traffic in the vicinity of Cook Inlet beluga critical habitat, a wide variety of anthropogenic noise sources are present. Many sources of anthropogenic noise are seasonal and occur during the ice-free months, although anthropogenic noise is present year-round. Sources include vessel noise from tugs, tankers, cargo ships, fishing vessels, small recreational vessels, dredging, pile-driving, military detonations, and seismic surveys (NMFS 2016b).

Literature reviews on the effects of sound on fish (Popper and Hastings 2009) conclude little is known about these effects and that it is not yet possible to extrapolate from one experiment to other signal parameters of the same noise, to other types of noise, to other effects, or to other species. Limited available scientific literature indicates that noise can evoke a variety of responses from fish. Pile driving can induce a startle response and/or an avoidance response, and can cause injury or death to fish close to the noise source (Casper et al. 2012; Halvorsen et al. 2012; McCauley et al. 2003; Slabbekoorn et al. 2010). It is likely that fish will avoid sound sources within ranges that may be harmful (McCauley et al. 2003).

Of all known Cook Inlet beluga prey species, only coho salmon (*Oncorhynchus kisutch*) have been studied for effects of exposure to pile driving noise (Casper et al. 2012, Halvorsen et al. 2012). These studies defined very high noise level exposures (210 dB re 1 μ Pa_{rms}) as threshold for onset of injury, and supported the hypothesis that one or two mild injuries resulting from pile driving exposure at these or higher levels are unlikely to affect the survival of the exposed animals in a laboratory environment. Rodkin (2009) studied the effects to juvenile coho salmon from pile driving of sheet piles at the Port of Anchorage in Knik Arm of Cook Inlet. The fish were exposed to *in-situ* noise from vibratory or impact pile driving at distances ranging from less than 1 m to more than 30 m. The results of this study showed no mortality of any test fish within 48 hours of exposure to the pile driving activities. Subsequent necropsies showed no effects or injuries as a result of the noise exposure. The effects of noise on other Cook Inlet beluga and Steller sea lion prey species, such as eulachon, gadids, and flounder species, is unknown (NMFS 2008b; NMFS 2016b).

5.6 Pollutants and Contaminants

5.6.1 Prudhoe Bay

5.6.1.1 Authorized Discharge

Discharges authorized from development activities occurring in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals) to ESA-listed species and their prey items (NMFS 2016b). Drill cuttings and fluids contain contaminants such as dibenzofuran and polycyclic aromatic hydrocarbons that have high potential for bioaccumulation. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea near the action area, and residues from these historical discharges may be present in the environment (Brown et al. 2010). Polycyclic aromatic

hydrocarbons are also emitted to the atmosphere by flaring water gases at production platforms or gas treatment facilities. For example, approximately 162,000 million standard cubic feet of waste gas was flared at Northstar in 2004 (Neff 2010).

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities in offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the United States. Section 403 of the CWA requires that EPA conduct an ocean discharge criteria evaluation for discharges of pollutants from point sources into the territorial seas, contiguous zones, and the oceans. The Ocean Discharge Criteria (40 CFR part 125, subpart M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued.

On November 28, 2012, EPA issued a NPDES general permit (GP) for discharges from oil and gas exploration facilities on the outer continental shelf and in contiguous state waters of the Beaufort Sea (Beaufort Sea Exploration GP). The general permit authorizes 13 types of discharges from exploration drilling operations and establishes effluent limitations and monitoring requirements for each waste stream.

On January 21, 2015, EPA issued a NPDES general permit for wastewater discharges associated with oil and gas geotechnical surveys and related activities in Federal waters of the Beaufort and Chukchi Seas (Geotechnical GP). This general permit authorizes twelve types of discharges from facilities engaged in oil and gas geotechnical surveys to evaluate the subsurface characteristics of the seafloor and related activities in federal waters of the Beaufort and Chukchi Seas.

Both the Beaufort Sea Exploration GP and the Geotechnical GP establish effluent limitations and monitoring requirements specific to each type of discharge and include seasonal prohibitions and area restrictions for specific waste streams. For example, both general permits prohibit the discharge of drilling fluids and drill cuttings to the Beaufort Sea from August 25 until fall bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik have been completed. Additionally, both general permits require environmental monitoring programs to be conducted at each drill site or geotechnical site location, corresponding to before, during, and after drilling activities, to evaluate the impacts of discharges from exploration and geotechnical activities on the marine environment.

The principal regulatory mechanism for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region OCS is also the CWA. The EPA issued a NPDES vessel general permit effective from December 19, 2013, to December 18, 2018, that applies to pollutant discharges from non-recreational vessels that are at least 24 m (79 ft) in length, as well as ballast water discharged from commercial vessels less than 24 m. This general permit restricts the seasons and areas of operation, as well as discharge depths, and includes monitoring requirements and other conditions.

In addition, the U.S. Coast Guard has issued regulations that address pollution prevention with respect to discharges from vessels carrying oil, noxious liquid substances, garbage, municipal or commercial waste, and ballast water (33 CFR part 151). The State of Alaska regulates water quality standards within three miles of the shore.

5.6.1.2 Spills

BOEM and BSEE define small oil spills as <1,000 barrels (bbl). Large oil spills are defined as 1,000-150,000 bbl, and very large oil spills (VLOS) are defined as $\geq 150,000$ bbl (BOEM 2017b).

Small Oil Spills

Offshore petroleum exploration activities have been conducted in State of Alaska waters adjacent of the Beaufort and Chukchi Seas since the late 1960s. Based on a review of potential discharges and on the historical oil spill occurrence data for the Alaska OCS and adjacent State of Alaska waters, several small spills in the Beaufort Sea from refueling operations (primarily at West Dock) were reported to the National Response Center. Small oil spills have occurred with routine frequency and are considered likely to occur (BOEM 2017b).

In the past 30 years, only 43 wells have been drilled in the Beaufort and Chukchi Sea lease program areas. From 1985 to 2013, eight crude oil spills of ≥ 550 bbl were documented along the Alaska North Slope, one of which was $\geq 1,000$ bbl. During the same time period, total North Slope production was 12.80 billion bbl (Bbbl) of crude oil and condensate. From 1971 through 2011, the highest mean volume of North Slope spills was from pipelines. The mean spill size for pipelines was 145 bbl. The spill rate for crude oil spills ≥ 500 bbl from pipelines (1985 to 2013) was 0.23 pipeline spills per Bbbl of oil produced (BOEM 2016c).

Large Oil Spills and Very Large Oil Spills

The large OCS spill-size assumption BOEM used for the Liberty spill analysis are based on reported spills in the Gulf of Mexico and Pacific OCS because no large spills ($\geq 1,000$ bbl) have occurred on the Alaska or Atlantic OCS from oil and gas activities (BOEM 2017c).

The loss of well control (LOWC) occurrence frequencies, per well, are on the order of 10^{-3} to 10^{-6} . The occurrence frequencies depend upon the operation or activity, whether the LOWC was a blowout or well release, and whether there was oil spilled (BOEM 2017c).

In general, historical data show that LOWC events escalating into blowouts and resulting in oil spills are infrequent and that those resulting in large accidental oil spills are even rarer events (BOEM 2017c). From 1964 to 2010 there were 283 well control incidents, 61 of which resulted in crude or condensate spills (BOEM 2012; BOEM 2017c). From 1971 to 2010, fewer than 50 well control incidents occurred. Excluding the volume from the Deepwater Horizon (DWH) spill, the total spilled volume was less than 2,000 bbl of crude or condensate, with the largest of the 1971-2010 spills—other than the DWH event—being 350 bbl. The DWH event was the only VLOS (3.19 million barrels of oil spilled) to occur between 1971 and 2010 (BOEM 2012; BOEM 2017c). During that same time period, more than 41,800 wells were drilled on the OCS and almost 16 Bbbl of oil were produced.

From 1971-2010, industry drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 (18 percent) resulted in oil spills ranging from 0.5 bbl to 200 bbl, for a total 354 bbl, excluding the estimated volume from the

DWH spill. These statistics show that, while approximately 15,000 exploration wells were drilled, there were a total of 15 loss-of-well-control events that resulted in a spill of any size: 14 were small spills and one was a large spill ($\geq 1,000$ bbl) that resulted in a blowout. That one large/very large spill was the DWH (BOEM 2017c).

The risk of an unlikely or rare event, such as a loss of well control incident, is determined using the best available historical data. The 2012-2017 Five-Year Program Final Programmatic EIS (BOEM 2012) provides a detailed discussion of the OCS well control incidents and risk factors that could contribute to a long duration LOWC event. Risk factors include geologic formation and hazards; water depth and hazards; geographic location (including water depth); well design and integrity; loss of well control prevention and intervention; scale and expansion; human error; containment capability; response capability; oil types and weathering/fate; and specific regional geographic considerations, including oceanography and meteorology (BOEM 2017c).

Quantifying the frequency of VLOSs from a loss of well control event is challenging as relatively few large oil spills that can serve as benchmarks have occurred on the OCS (Scarlett et al. 2011). Based on an analysis of this historic data from both the 1971-2010 (the modern regulatory era) and the 1964-1971 time frames, the frequency of a loss of well control occurring and resulting in a VLOS of different volumes was determined (BOEM 2016b). This analysis, which is set forth in the 2017-2022 Five-Year Program Final Programmatic EIS for the Liberty Development Project, was used to calculate the frequency (per well) of a spill exceeding 4,610,000 bbl (BOEM 2017c).

5.6.1.3 Contaminants Found in Listed Species

Metals and hydrocarbons introduced into the marine environment from offshore exploratory drilling activities are not likely to enter the Beaufort Sea food webs in ecologically significant amounts. However, there is a growing body of scientific literature on concentrations of metals and organochlorine chemicals (e.g., pesticides and polychlorinated biphenyls [PCBs]) in tissues of higher trophic level marine species, such as marine mammals, in cold-water environments. There is particular concern about mercury in Arctic marine mammal food webs (MacDonald 2005). Mercury concentrations in marine waters in much of the Arctic are higher than concentrations in temperate and tropical waters due in large part to deposition of metallic and inorganic mercury from long-range transport and deposition from the atmosphere (Outridge et al. 2008). However, there is no evidence that significant amounts of mercury are coming from oil operations around Prudhoe Bay (Snyder-Conn et al. 1997) or from offshore drilling operations (Neff 2010).

Bowhead Whales

Some environmental contaminants, such as chlorinated pesticides, are lipophilic and can be found in the blubber of marine mammals (Becker et al. 1995). Tissues collected from whales landed at Barrow in 1992 (Becker et al. 1995) indicated that bowhead whales had very low levels of mercury, PCBs, and chlorinated hydrocarbons, but they had elevated concentrations of cadmium in their liver and kidneys. Bratton et al. (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98 percent of the total arsenic was arsenobetaine. Arsenobetaine is a common substance in marine biological systems and is relatively non-toxic.

Bratton et al. (1993) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowhead whales harvested from 1983 to 1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time. The metal levels observed in all tissues of the bowhead are similar to levels reported in the literature in other baleen whales. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium. Mossner and Ballschmiter (1997) reported that total levels of polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific and Arctic Oceans were many times lower than those in beluga whales or northern fur seals. However, while total levels were low, the combined level of three isomers of the hexachlorocyclohexanes (chlorinated pesticides) was higher in the blubber tested from bowhead whales than from three marine mammal species sampled in the North Atlantic (pilot whale, common dolphin, and harbor seal). These results were believed to be due to the lower trophic level of the bowhead as compared to the other marine mammals tested.

Ringed and Bearded Seals

Contaminants research on ringed seals is extensive throughout the Arctic environment where ringed seals are an important part of the diet for coastal human communities. Pollutants such as organochlorine compounds and heavy metals have been found in all of the subspecies of ringed seal (with the exception of the Okhotsk ringed seal). The variety, sources, and transport mechanisms of contaminants vary across ringed seal ecosystems (Kelly et al. 2010b). Heavy metals such as mercury, cadmium, lead, selenium, arsenic, and nickel accumulate in ringed seal vital organs, including liver and kidneys, as well as in the central nervous system (Kelly et al 2010b). Gaden et al. (2009) suggested that during ice-free periods the seals eat more Arctic cod (and mercury). They also found that mercury levels increased with age for both sexes (Dehn et al. 2005; Gaden et al. 2009). Becker et al. (1995) reported ringed seals had higher levels of arsenic in Norton Sound (inlet in the Bering Sea) than ringed seals taken by residents of Point Hope, Point Lay, and Barrow (now Utqiagvik). Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources.

Research on contaminants in bearded seals is limited compared to the information for ringed seals. However, pollutants such as organochlorine compounds and heavy metals have been found in most bearded seal populations. Climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic (Tynan and Demaster 1997).

5.6.2 Marine Transit Route

Along the marine transit route, the most likely sources of pollution and contaminants would be ballast water discharge and accidental spills of oil, fuel, and other materials from traversing vessels.

The Aleutian Islands had the greatest volume of reported oil and other hazardous substance spills in marine waters between 1995 and 2012. Leaks and spills have been reported from fuel tanks and tank farms in the Unalaska area of the marine transit route. The State of Alaska Department of Environmental Conservation (ADEC) listed Dutch Harbor as “impaired” on the 1990 Clean

Water Act section 303(d) list of impaired waters due to non-attainment of water quality standard for petroleum hydrocarbons and petroleum products (i.e., oil and grease). In its 2010 (i.e., most recent) section 303(d) total maximum daily load assessment of the area, ADEC found that Dutch Harbor met applicable water quality standards and removed the waterbody from the 303(d) list. However, areas of Dutch Harbor are still considered impaired due to oil sheens in sediments (ADEC 2010). The 2010 report found that Dutch Harbor was among the most impacted areas within the areas reported in Unalaska, with contamination more likely to occur around active docks. The potential sources of this contamination include several previously contaminated sites nearby as well as many industrial sources that currently operate within the harbor area. OASIS Environmental Inc. (2006) provides more information on contaminants at Dutch Harbor.

5.6.3 Cook Inlet

Upper Cook Inlet was designated as a Category 3 on the Clean Water Act (CWA) Section 303(d) list of impaired water bodies by ADEC (ADEC 2013), indicating there is insufficient data to determine whether the water quality standards for any designated uses are attained. Lower Cook Inlet is not listed as an impaired waterbody due to lack of information to the contrary; however, ADEC determined that the overall condition of Southcentral Alaska coastal waters were rated as good based on examining water quality, sediment quality, and fish tissue contaminants collected from 55 sites in the survey area (ADEC 2013).

The Cook Inlet region is the most populated and industrialized region of the state. Its waters receive various pollutant loads through activities that include urban runoff, oil and gas activities (e.g., discharges of drilling muds and cuttings, production waters, treated sewage effluent discharge, deck drainage), municipal sewage treatment effluents, oil and other chemical spills, fish processing, and other regulated discharges. Many pollutants are regulated by either EPA or ADEC, who may authorize certain discharges under the National (or Alaska) Pollution Discharge Elimination System (NPDES/APDES; section 402 of the CWA of 1972). It is necessary to manage pollutants and toxins to protect and maintain the biological, ecological, and aesthetic integrity of these waters.

The Recovery Plan for the Cook Inlet Beluga Whale (NMFS 2016b) states that exposure to industrial chemicals, as well as to natural substances released into the marine environment, is a potential health threat for Cook Inlet belugas and their prey. An in-depth review of available information on pollution and contaminants in Cook Inlet is presented in the Recovery Plan.

Cook Inlet beluga whales are exposed to chemical concentrations that are typically lower than those experienced by Arctic marine mammals (Becker et al. 2000; Becker et al. 2010). Levels of heavy metals, pesticides, petroleum hydrocarbons, and PCB compounds found in Cook Inlet's water column and sediments were below detection limits; and heavy metal concentrations were below management levels (KABATA 2004; NMFS 2008a; USACE 2008).

5.6.3.1 Authorized Discharge

Wastewater Discharge

Ten communities currently discharge treated municipal wastes into Cook Inlet. Wastewaters entering these plants may contain a variety of organic and inorganic pollutants, metals, nutrients, sediments, bacteria and viruses, and other emerging pollutants of concern. Wastewater from the Municipality of Anchorage, Nanwalek, Port Graham, Seldovia, and Tyonek receive primary treatment, wastewaters from Homer, Kenai, and Palmer receive secondary treatment, and wastewaters from Eagle River and Girdwood receive tertiary treatment.

Wastewater treatment facilities undergo primary, secondary, or tertiary treatment prior to being discharged into a body of water. Primary treatment involves sedimentation. In general, this includes removing 50 to 70 percent of the solid particulate from the wastewater prior to discharge (Sonune and Ghate 2004). In addition to sedimentation, secondary treatment involves adding a biological component to remove the remaining organic matter. Tertiary treatment involves both primary and secondary treatment as well as additional processes to increase the water quality of the discharge (Sonune and Ghate 2004).

The Anchorage John M. Asplund Wastewater Treatment Facility (AWTF) is the largest wastewater facility in Alaska and is located in upper Cook Inlet, within the action area. AWTF provides primary treatment only and removes approximately 80 percent of solids prior to discharge. The facility was built in 1972, upgraded in 1982 (28 million gallons per day [mgd]), and then upgraded again in 1989 (58 mgd). The EPA issues a waiver to AWTF for secondary treatment and allows the direct discharge of wastewater into Cook Inlet near Point Woronzof once the wastewater has undergone primary treatment. AWTF is allowed to discharge primary treated wastewater due to the levels of sediment they are able to extract and the extreme tides and currents of Cook Inlet¹⁵. Once the sediment is removed from the wastewater, the sludge is incinerated.

The Village of Tyonek wastewater treatment facility, located near the portion of Cook Inlet most heavily used by feeding Cook Inlet beluga whales, provides primary treatment prior to wastewater discharge. Tyonek operates on a gravity fed sewer that drains into a community septic tank. Every spring and fall, the solids are transferred to a sludge lagoon for dewatering. The liquid effluent is then discharged into Cook Inlet. The village uses approximately 60 gallons of water per day, most of which ends up as discharged liquid effluent.

The City of Kenai wastewater facility is one of the larger wastewater treatment facilities in Cook Inlet and is located near the largest runs of salmon in Cook Inlet. The Kenai wastewater treatment facility discharges secondary treated wastewater from its treatment plant directly into Cook Inlet, and the sludge is taken to the Soldotna landfill. The facility's design flow is 1.330 mgd with an average daily flow of 0.573 mgd. The City of Kenai began upgrades to the facility in 2018, and will continue upgrades in 2020.

Wastewater discharge from oil and gas development could increase pollutants in Cook Inlet (NMFS 2008a). Discharge includes but are not limited to drilling fluids (muds and cuttings), produced water (water phase of liquid pumped from oil wells), and domestic and sanitary

waste (EPA 2015; NMFS 2008a). Under the NPDES permit issued by EPA, oil and gas facilities are required to monitor the effluent for pollutants and meet standards specified in the permit before it is discharged into Cook Inlet (EPA 2015).

Mixing Zones

In 2010, EPA consulted with NMFS on the approval of ADEC's Mixing Zone Regulation section [18 Alaska Administrative Code (AAC) 70.240], including most recent revisions, of the Alaska Water Quality Standards [18 AAC 70; WQS] relative to the endangered Cook Inlet beluga whale (NMFS 2010b). The 2010 biological opinion concluded that there was insufficient information to conclude whether belugas could be harmed by the elevated concentrations of substances present in mixing zones, but that the action was not likely to jeopardize the continued existence of the species. The 2010 opinion did not address the effects of the proposed action on Cook Inlet beluga whale critical habitat, which NMFS designated in 2011. In 2019, NMFS issued a biological opinion on the effects of EPA approval of the Mixing Zone Regulation following designation of Cook Inlet beluga whale critical habitat and concluded that the Mixing Zone Regulation is not likely to destroy or adversely modify designated Cook Inlet beluga whale critical habitat.

Ballast Water

Ballast water discharge from ships is another source of potential pollution as well as potential release of non-indigenous organisms into Cook Inlet. Information and statistics on ballast water management in Cook Inlet can be found at: <https://www.circac.org/wp-content/uploads/2003nov-Cook-Inlet-Ballast-Water-Catalogue-Nuka.pdf>.

Discharges of wastes from vessels are regulated by the United States Coast Guard. Potential discharges include oily waste, sewer water, gray water (e.g., shower water), ballast water that may contain invasive marine species, and garbage. Gray water and sewer water, provided that they are free from oil waste, may be discharged in the open sea.

Ships can potentially release pollutants and non-indigenous organisms into Cook Inlet through the discharge of ballast water. It is a recognized worldwide problem that marine organisms picked up in ship ballast water, transported to foreign lands, and dumped into non-native habitats are responsible for significant ecological and economic perturbations costing billions of dollars. The National Ballast Information Clearinghouse reported that more than five million metric tons of ballast water was released in Cook Inlet, from Homer to Anchorage, between 1999 and 2003. Invasive species were found just off the POA in a 2004 survey by the Smithsonian Environmental Research Center. The effects of discharged ballast water and possible invasive species from such discharges on fin whales, humpback whales, and Cook Inlet beluga whales and Cook Inlet beluga designated critical habitat are unknown. In order to try to protect Alaska's waters, ADFG developed an Aquatic Nuisance Species Management Plan (Fay 2002). Information and statistics ballast water management in Cook Inlet can be found at: <https://www.circac.org/wp-content/uploads/2003nov-Cook-Inlet-Ballast-Water-Catalogue-Nuka.pdf>

5.6.3.2 Spills

Given the amount of oil and gas production and vessel traffic, spills of petroleum products are a threat to marine mammals inhabiting Cook Inlet. Research indicates cetaceans are capable of detecting oil, but they do not seem to avoid it (Geraci and St. Aubin 1990). Oil spills that occur in or upstream of Cook Inlet could result in marine mammals experiencing direct contact with the oil, with possible effects to skin and/or respiratory systems. Cook Inlet beluga whales could be affected through residual oil from a spill, even if they were not present during the oil spill, due to the highly mobile nature of oil in water and the extreme tidal fluctuations in Cook Inlet (NMFS 2008a). Prey contamination is also likely, but the effect of contaminated prey on belugas remains unknown. Spill clean-up efforts could also result in displacement of whales from essential feeding areas.

Polycyclic aromatic hydrocarbons, a group of contaminants found in petroleum products, combined with other contaminants, may cause cancer in beluga whales (Kingsley 2002) and are otherwise a concern with respect to the conservation and recovery of the Cook Inlet beluga whale. Cook Inlet belugas appear to be bioaccumulating polycyclic aromatic hydrocarbons from the environment and prey (Norman et al. 2015).

While construction of an oil/gas facility may result in a small amount of habitat loss, an oil spill in Cook Inlet could result in widespread habitat degradation impacting beluga whales and putting the population at risk. Individuals from the listed humpback whales within Cook Inlet may also be put at risk due to such a spill, but population level effects would be far less likely, unless the spill was sufficiently large to impact areas outside Cook Inlet.

It is not known whether humpback whales avoid oil spills; however, humpbacks have been observed feeding in a small oil spill on Georges Bank (NMFS 1991). The greatest impacts of oil spills on humpbacks could occur indirectly. Local depletion of food resources may occur as a result of displacement and mortality of their food resources, many of which are highly susceptible to the toxic effects of oil and are essentially unable to move away from the site of a spill. Other more mobile prey species may suffer from mortality of eggs and immature life stages (NMFS 1991), possibly reducing future availability of prey.

Oil Spills

According to the ADEC's oil spills database, oil spills in marine waters consist mostly of harbor and vessel spills, and spills from platform and processing facilities. A reported 477,942 liters (126,259 gal) (from 79 spills) of oil was discharged in the Cook Inlet area since July 1, 2013, primarily from vessels and harbor activities and from exploration and production facilities. Three of the ten largest spills in Alaska during state fiscal year 2014 occurred in Cook Inlet; these included 84,000 gallons of produced water by Hilcorp in the Kenai gas field; 9,100 gallons of process water released by the Tesoro API Tank Bypass Spill; and a Flint Hills, Anchorage spill of 4,273 gallons of gasoline (ADEC 2015).

A spill baseline study conducted as part of the Cook Inlet Risk Assessment estimated a historical vessel spill rate of 3.4 spills (regardless of size) per year, with 3.9 spills per year forecasted for the years 2015 through 2020 across all vessel categories (Nuka Research and Planning and Pearson Consulting LLC 2015). Historical rates ranged from 0.7 spills per year for tank ships to

1.3 spills per year for non-tank/non-workboat vessels (Nuka Research and Planning and Pearson Consulting LLC 2015). Eight large spills (≥ 1000 bbl) from vessels (tankers and, in one case, a tug) are documented in Cook Inlet between 1966 and 2015 (BOEM 2016a). No large spills have occurred in the area in recent years (BOEM 2017a).

On April 1, 2017, an oil spill was detected off the Anna Platform in Cook Inlet. Hilcorp reported the incident to ADEC on the same day. Documentation from Hilcorp indicates the release resulted from an accident on the Anna Platform production facility flare system. It was estimated a maximum of three gallons of oil was discharged into the marine environment. Subsequent to these accidents, Hilcorp has updated their Integrity Management Plan.

The Anna Platform experienced a diesel beam tank spill of 441 gallons on January 24, 2018. All the diesel was recovered and recycled. Hilcorp has also reported recent minor spills (< 200 gallons) of drilling mud from the Steelhead and Granite Platforms and a glycol spill from the Bruce Platform, with most or all spilled material recovered.

The ADEC Statewide Oil Spills Database⁵ has records of three spills in Cook Inlet in 2019, a release of 0.1 lb of natural gas from Hilcorp Platform A in Trading Bay on April 27, 2019 which naturally dispersed, a 42 gal spill of crude oil from the Drift River Terminal also on April 27, 2019 for which the disposal method was not reported, and an onshore spill of 210 gal of crude oil at the Hilcorp MGS Onshore Facility in Nikiski on April 15, 2019. The disposal method for the onshore spill was not reported, but it appears to have been contained to land and did not enter the marine environment. A fourth incident was reported to ADEC on May 1, 2019 consisting of a multi-day gas leak of unknown quantity at Hilcorp's Platform A.

Natural Gas Spills

On February 7, 2017, a Hilcorp helicopter flying between Nikiski and Platform A identified bubbles resulting from a natural gas leak in one of their pipelines. The gas leak was reported to the National Response Center and ADEC. Subsequent Hilcorp data revealed that the leak had been occurring since late December. The initial estimated leak rate was between 225,000 to 325,000 cubic feet per day from an eight-inch pipeline 80 ft below Cook Inlet waters (Hilcorp 2017). The cause of the release was a large rock that caused a breach in the line.

Hilcorp worked closely with NMFS, the Pipeline and Hazardous Materials Safety Administration, ADEC, and other stakeholders to conduct mitigation and monitoring actions during the gas release and subsequent repair. Initially, Hilcorp significantly reduced gas flow through the line, but did not shut down the line completely for fear of residual oil leaking into the marine environment. Divers installed a temporary pipeline clamp on April 13, 2017, but due to weather and ice conditions, a permanent repair was not completed until May 19, 2017. Limited aerial surveys of wildlife in the vicinity of the leak did not indicate the presence of any marine mammals near the leak (Hilcorp unpublished data).

⁵ <https://dec.alaska.gov/spar/ppr/spill-information/spill-data/> Accessed May 20, 2020.

Other Sources of Discharge

Stormwater Runoff

Stormwater pollutants may include street and aircraft deicer, oil, pesticides and fertilizers, heavy metals, and fecal coliform bacteria. Public Works and the Alaska Department of Transportation and Public Facilities are responsible for identifying, monitoring, and controlling pollutants in stormwater. Stormwater from other communities in the action area (e.g., Kenai) may also contribute to pollutants that enter Cook Inlet. The effects of stormwater on the Cook Inlet beluga whale have not been studied and are unknown (NMFS 2008a).

Numerous releases of petroleum hydrocarbons have been documented from the POA, JBER, and the Alaska Railroad Corporation. The POA transfers and stores petroleum oils, as well as other hazardous materials; and since 1992, all significant spills and leaks have been reported. Past spills have been documented at each of the bulk fuel facilities within the POA and also on JBER's property (POA 2003).

JBER is listed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, because of known or threatened releases of hazardous substances, pollutants, or contaminants. Spills have also been reported at the Alaska Railroad Corporation rail yard. In 1986, petroleum seeped into Ship Creek from the nearby rail yard, and several oil spills occurred in 2001 (Army 2010). Freight handling activities have historically caused numerous surface stains and spills at the rail yard.

Aircraft De-icing

Airport deicing contributes to the levels of pollutants found in Cook Inlet. Deicing and anti-icing of aircraft and airfield surfaces are required by the Federal Aviation Administration to ensure the safety of passengers. Deicing and anti-icing chemicals are used from October through May and may be used on aircraft, tarmacs, and runways. Depending on the application, deicing material is comprised of different chemicals. Ethylene glycol and propylene glycol are used on aircraft for anti-icing and deicing purposes, whereas potassium acetate and urea are used to deice tarmacs and runways. Much of the deicing material or their breakdown products eventually enter Cook Inlet. No studies exist analyzing the potential impacts on beluga whales from these deicing agents.

The Ted Stevens Anchorage International Airport and JBER airport are the largest airports in the Cook Inlet region. Other smaller airports exist throughout the Cook Inlet watershed, including Merrill Field, Lake Hood, and Lake Spenard (NMFS 2008a).

5.6.3.3 Contaminants Found in Listed Species

Studies conducted in upper Cook Inlet, in areas of high concentrations of beluga whales, found levels of PCBs, pesticides, and petroleum hydrocarbons in the water column and sediment were below detectable limits and levels of heavy metals were below management levels (KABATA 2004, NMFS 2008a, USACE 2008).

Becker et al. (2000) compared tissue samples taken from harvested Cook Inlet beluga whales from two Arctic Alaskan populations, Greenland, Arctic Canada, and the St. Lawrence Estuary beluga population. They compared levels of PCBs, chlorinated pesticides, heavy metals, and other elements between populations. The results indicated that the Cook Inlet population had the lowest concentrations of PCBs, pesticides, cadmium, and mercury of all these populations, but had higher concentrations of copper than the other Arctic populations. Becker et al. (2000) suggested the difference in toxin levels was likely related to a difference in source (geographic or food web) and age distribution of the animals. A follow up study conducted by Becker et al. (2010) did not find significant changes in contaminant levels in the Cook Inlet beluga whale population with the inclusion of additional samples collected over the past decade; however, they did identify and document increasing levels of chemicals of emerging concern (e.g., polybrominated diphenyl ether, hexabromocyclododecane, and perfluorinated compounds) in the Cook Inlet population. Although the levels of contaminants found in the Cook Inlet beluga whale population are lower than levels found in other populations, the effects of these contaminants on this population are unknown (Becker et al. 2000, NMFS 2008a).

5.7 Direct Mortality

Within the proposed action area there are several potential sources of direct anthropogenic mortality, including subsistence harvest, stranding, and predation. Direct mortality associated with vessels strikes is addressed in Section 5.4.

5.7.1 Prudhoe Bay and Marine Transit Route

5.7.1.1 Subsistence Harvest

The ESA and MMPA allow for the harvest of marine mammals by Alaska Natives for subsistence purposes and for traditional handicrafts. Subsistence hunters in Alaska are not authorized to take humpback whales (Muto et al. 2018). However, one humpback whale was illegally harvested in Kotlik in October, 2006, and another was illegally harvested in Toksook Bay in May, 2016.

Whaling by Alaska Natives in the Alaskan Arctic and sub-arctic has taken place for at least 2,000 years (Marquette and Bockstoce 1980; Stoker and Krupnik 1993). In addition to subsistence hunting, commercial whaling occurred during the late 19th and early 20th centuries. Pelagic commercial whaling for the Western Arctic stock of bowheads was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort Seas (Bockstoce et al. 2005). Woodby and Botkin (1993) estimated that the historical abundance of bowhead whales in this population was between 10,400 and 23,000 whales before commercial whaling began. Within the first two decades (1850 through 1870), over 60 percent of the estimated pre-whaling population was harvested, although whaling effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 whales from this stock (Woodby and Botkin 1993). Between 1848 and 1919, shore-based whaling operations (including landings as well as struck and lost estimates from U. S., Canada, and Russia) took an additional 1,527 animals (Woodby and Botkin 1993). Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals. Commercial whaling also may have caused the extinction of

some subpopulations and some temporary changes in distribution.

Subsistence harvest has been regulated by quotas set by the IWC and allocated by the Alaska Eskimo Whaling Commission since 1977. Alaska Native subsistence hunters, primarily from 11 Alaska communities, take approximately 0.1 to 0.5 percent of the population per annum (Philo et al. 1993; Suydam et al. 2011). Under this quota, the number of kills in any one year has ranged between 14 and 72. The maximum number of strikes per year is set by a quota which is determined by subsistence needs and bowhead whale abundance and trend estimates (Stoker and Krupnik 1993). Suydam and George (2012) summarized Alaska subsistence harvests of bowhead whales from 1974 to 2011 by village and reported that a total of 1,149 whales were landed by hunters from 12 villages, with Barrow (now Utqiagvik) landing the most whales (n = 590) and Shaktoolik landing only one. The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions (Table 42). The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead whale quota in 1978. In 1978, the efficiency was about 50 percent. In 2016, 47 of 59 whales struck were landed, resulting in an efficiency of 80 percent, which was slightly higher than the previous 10-year average of 75 percent (Suydam et al. 2017).

Table 42. Annual number of bowhead whales landed by Alaska natives

Year	Number of Landed Whales
2010	45
2011	38
2012	55
2013	46
2014	38
2015	38
2016	47
2017	43
Sources: (Suydam et al. 2011; Suydam et al. 2012; Suydam et al. 2014; Suydam et al. 2013; Suydam et al. 2015; Suydam et al. 2016; Suydam et al. 2017, AEWG unpublished data, 2017)	

Canadian and Russian Natives also take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. No catches for Western Arctic bowhead whales were reported by either Canadian or Russian hunters for 2006 and 2007 (IWC 2008; IWC 2009) or by Russia in 2009, 2011, 2012, or 2014 (Ilyashenko 2013; Ilyashenko and Zharijov 2015; IWC 2011), but two bowhead whales were taken in Russia in 2008 (IWC 2010), two in 2010 (IWC 2012), and one in 2013 (Ilyashenko and Zharijov 2014).

Annual subsistence take by Natives of Alaska, Russia, and Canada from 2010 through 2014 averaged 44 bowhead whales. During the 2013 through 2018 time period, the IWC and Alaska

Eskimo Whaling Commission (AEWC) allowed Alaskan and Chukotkan whalers to land up to 336 bowhead whales total (AEWC 2018). The IWC set a catch limit of 392 bowhead whales landed for the years 2019 through 2025 combined.

Ringed and bearded seals are important subsistence species for many northern coastal communities. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ringed and bearded seals for subsistence purposes (Ice Seal Committee 2016). Estimates of subsistence harvest of ringed and bearded seals are available for 17 of these communities based on annual household surveys conducted from 2009 through 2014 (Table 43), but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. Household surveys are designed to estimate harvest for the specific community surveyed; extrapolation of harvest estimates beyond a specific community is not appropriate because of local differences in seal availability, cultural hunting practices, and environmental conditions (Ice Seal Committee 2017). During 2010 through 2014, the total annual ringed and bearded seal harvest estimates across surveyed communities ranged from 695 to 1,286 and 217 to 1,176, respectively (Table 43). However, it should be noted that the geographic distribution of communities surveyed varied among years such that these totals may be geographically or otherwise biased.

Table 43. Alaska ringed and bearded seal harvest estimates based on household surveys, 2010–2014 (Ice Seal Committee 2017)

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Nuiqsut	-	-	-	-	58	-	-	-	-	26
Utqiagvik	-	-	-	-	428	-	-	-	-	1,070
Point Lay	-	-	51	-	-	-	-	55	-	-
Kivalina	-	16	-	-	-	-	123	-	-	-
Noatak	-	3	-	-	-	-	65	-	-	-
Buckland	-	26	-	-	-	-	48	-	-	-
Deering	-	0	-	-	-	-	49	-	-	-
Golovin	-	-	0	-	-	-	-	11	-	-
Emmonak	-	56	-	-	-	-	106	-	-	-
Scammon Bay	-	137	169	-	-	-	82	51	-	-
Hooper Bay	458	674	651	667	158	148	210	212	171	64
Tununak	162	257	219	-	-	40	42	44	-	-
Tuntutuliak	-	-	-	75	-	-	-	-	53	-
Quinhagak	163	117	140	160	51	29	26	44	49	16
Togiak	1	0	-	-	-	0	2	-	-	-

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Twin Hills	0	-	-	-	-	0	-	-	-	-
Dillingham	-	-	3	-	-	-	-	7	-	-
Total	784	1,286	1,233	902	695	217	753	424	273	1,176

Source: (Ice Seal Committee 2017)

5.7.1.2 Stranding

Since 2003, there have been 14 reports of beached, dead bowhead whales ranging from Utqiagvik to Nome (NMFS unpublished data). The cause of death is unknown for most of these reports as the level of decomposition was too advanced.

The NMFS AKR Stranding Network received reports of many stranded ice seals in spring and summer 2019. In September, NMFS declared an Unusual Mortality Event (UME) for ringed, bearded, and spotted seals, dating back to June 1, 2018. From June 2018 through April 15, 2020, there were reports of 66 ringed, 84 bearded, and 85 unidentified seals (a number of which could have been ringed or bearded seals). The cause, or causes, of these deaths is currently being investigated by NMFS.

From December 2017 – May 2018, there were 28 ringed seal strandings in the Bering Sea, reported in the villages of Unalaska, Akutan, Nelson Lagoon, and St. Paul. Health evaluations were conducted for the seals, but it is still unclear if these incidences were outliers or indicators of the potential negative effects of climate change (Savage 2019).

5.7.1.3 Predation

Little is known about the natural mortality of bowhead whales (Philo et al. 1993). From 1964 through the early 1990s, at least 36 deaths were reported in Alaska, Norway, Yukon and Northwest Territories for which the cause could not be established (Philo et al. 1993). Bowhead whales have no known predators except humans and killer whales. The frequency of attacks by killer whales upon the Western Arctic stock of bowhead whales is assumed to be low (George et al. 1994). Of 195 whales examined from the Alaskan subsistence harvest between 1976 and 1992, 4.1 to 7.9 percent had scars indicating that they had survived attacks by killer whales (George et al. 1994). Of 378 complete records for killer whale scars collected from 1990 to 2012, 30 whales (8 percent) had scarring “rake marks” consistent with orca/killer whale injuries and another 10 had possible injuries (George et al. 2017).

Polar bears are the main predator of ringed and bearded seals (Cameron et al. 2010; Kelly et al. 2010b). Other predators of both species include walrus and killer whales (Burns and Eley 1976; Derocher et al. 2004; Fay et al. 1990; Heptner et al. 1976; Melnikov and Zagrebina 2005). In addition, Arctic foxes prey on ringed seal pups by burrowing into lairs; and gulls, ravens, and possibly snowy owls successfully prey on pups when they are not concealed in lairs (Kelly et al. 1986; Lydersen 1998; Lydersen et al. 1987; Lydersen and Ryg 1990; Lydersen and Smith 1989; Smith 1976). The threat currently posed to ringed and bearded seals by predation is considered

moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate (Cameron et al. 2010; Kelly et al. 2010b).

5.7.2 Cook Inlet

5.7.2.1 Subsistence Harvest

The effect from past subsistence harvests on the Cook Inlet beluga whale population was significant. While an unknown amount of harvest occurred for decades or longer, the subsistence harvest levels increased substantially in the 1980s and 1990s to unsustainable levels. Reported subsistence harvests during 1994-1998 probably account for the stock's decline during that interval. In 1999, beluga whale subsistence harvest discontinued as a result of both a voluntary moratorium by the hunters that spring, and Public Law 106-553 section 627, which required hunting of Cook Inlet beluga whale for subsistence uses be conducted pursuant to a cooperative agreement between NMFS and affected Alaska Native organizations. In 2005, a co-management agreement allowed the harvest of two whales. In 2006, the co-management agreement allowed the harvest of one whale, however no whales were taken due to poor weather, and hunters' avoidance of females with calves.

In 2008, NMFS issued regulations (73 FR 60976; October 15, 2008) establishing long-term limits on the maximum number of Cook Inlet beluga whales that may be taken for subsistence by Alaska Natives. These long-term harvest limits, developed for five-year intervals, require that the abundance estimates reach a minimum five-year average of 350 belugas (50 CFR 216.23(f)(2)(v)). No hunt has been authorized since 2006.

5.7.2.2 Stranding

Live stranding occurs when a marine mammal is found in waters too shallow to swim. Cook Inlet beluga whales are probably predisposed to stranding because they breed, feed, and molt in the shallow waters of upper Cook Inlet where extreme tidal fluctuations occur. However, stranding events that last more than a few hours may result in mortalities. Strandings can be intentional (e.g., to avoid killer whale predation), accidental (e.g., chasing prey into shallows then becoming trapped by receding tide), or a result of injury, illness, or death.

An estimated 876-953 live beluga strandings and a total of 214 dead beluga beachings have been documented in Cook Inlet from 1988 through 2015 (NMFS 2016b). Beluga whale stranding events may represent a significant threat to the conservation and recovery of this stock.

In nearly all known cases, strandings of humpback whales represent animals that died at sea of various other causes and washed ashore; a young humpback whale live stranded on mud in Turnagain Arm in April 2019, and while it freed itself on an incoming tide at one point, the animal later died.

5.7.2.3 Predation

Killer whales are the only natural predators for beluga whales in Cook Inlet (Muto et al. 2018). Beluga whale stranding events have also been correlated with killer whale presence, and Native hunters report that beluga whales intentionally strand themselves in order to escape killer whale

predation (Huntington 2000b). Killer whale sightings were not well-documented and were likely rare in the upper inlet prior to the mid-1980s. From 1982 through 2014, 29 killer whale sightings in upper Cook Inlet (north of the East and West Forelands) were reported to NMFS. It is not known which of these were mammal-eating killer whales (i.e., transient killer whales) that might prey on beluga whales or fish-eating killer whales (i.e., resident killer whales) that would not prey on beluga whales.

Between 9 and 12 beluga whale deaths during this time (1982-2014) were suspected to be a direct result of killer whale predation (NMFS 2016b). From 2011 through 2014, NMFS received no reports of killer whale sightings in upper Cook Inlet or possible predation attempts. Prior to 2000, an average of one Cook Inlet beluga whale was killed annually by killer whales (Shelden et al. 2003). During 2001-2012 only three Cook Inlet beluga whales were reported as preyed upon by killer whales (NMFS unpublished data). This is likely an underestimate, however, as the remains of preyed-upon belugas may sink and go undetected by humans. Killer whale predation has been reported to have a potentially significant impact on the Cook Inlet beluga whale population (Shelden et al. 2003).

5.8 Research

Research is a necessary endeavor to assist in the recovery of threatened and endangered species; however, research activities can also disturb these animals. Research on marine mammals often requires boats, adding to the vessel traffic, noise, and pollution near the action area. Aerial surveys could also disturb whales, especially when circling at low-altitudes to obtain accurate group counts occurs. Boat based surveys, such as photo-identification studies, often require the boat to closely approach whales or whale groups. Deployment and retrieval of passive acoustic monitoring devices requires a boat, which temporarily increases noise in the immediate area. However, once the instruments are deployed, passive acoustic monitoring is noninvasive.

NMFS issues scientific research permits that are valid for five years for ESA-listed species. When permits expire, researchers often apply for a new permit to continue their research. Additionally, applications for new permits are issued on an on-going basis.

Species considered in this Biological Opinion are also taken incidentally during research directed towards other species. This includes various hydroacoustic surveys for fish species, the Alaska longline survey, the Arctic ecosystem integrated survey, and other research (NMFS 2019).

The following information on research is applicable to ESA-listed species throughout the proposed project action area, and thus is not broken out by geographic location like other subsections in the Environmental Baseline.

5.8.1 Cetaceans

Whales are exposed to research activities documenting their biology, behavior, habitat use, stock structure, social organization, communication, distribution, and movements throughout their ranges. Activities associated with these permits occur in the action area, in some cases at the same time as the proposed project activities.

Currently permitted research activities include:

- Counting/surveying, aerial and vessel-based
- Opportunistic collection of sloughed skin and remains
- Behavioral and monitoring observations
- Various types of photography and videography
- Skin and blubber biopsy sampling
- Fecal sampling
- Suction-cup, dart/barb, satellite, and dorsal fin/ridge tagging
- Acoustic, active playback/broadcast, and passive recording
- Acoustic sonar for prey mapping

Some of these research activities require close vessel approach. The permits also include incidental harassment takes to cover such activities as tagging, where the research vessel may come within 100 yards of other whales while in pursuit of a target whale. These activities may cause stress to individual whales and cause behavioral responses. In some cases, take could occur and is authorized.

Research activities can be more invasive, especially when they include animal capture, collecting blood and tissue samples, or attaching tracking devices such as satellite tags. In the worst case, research can result in deaths of the animals. Between 1999 and 2002, NMFS placed satellite tags on 18 beluga whales in upper Cook Inlet (Hobbs et al. 2005). Shortly after a tagging event in 2002, a tagged beluga whale was found dead; its tag had transmitted for only 32 hours. Another two tagged beluga whales transmitted data for less than 48 hours, with similar dive patterns; it is unknown whether these whales, tagged in the same manner as the one that died, also perished, or were fitted with defective tags (NMFS, unpublished data). In 2015, an additional animal previously tagged by researchers washed up dead, with infection at the site of instrument attachment implicated as a possible cause of death.

Although research may affect beluga whales, it is anticipated that research will continue to increase because there are many remaining data gaps on Cook Inlet beluga whale biology and ecology (NMFS 2016b). However, managers are cautious in permitting only minimally invasive research techniques. There have been no known instances of research-related deaths of humpback whales in Cook Inlet.

5.8.2 Pinnipeds

Ringed seals and bearded seals are exposed to research activities documenting their population status and trends, health, movements, habitat use, foraging ecology, response to recovery activities, distribution, and movements throughout their ranges.

Of the more than 30 active scientific research permits, some include behavioral observations, counting/surveying, photo-identification, and capture and restraint (by hand, net, cage, or board), for the purposes of collecting the following samples/information:

- Blood
- Clipped hair
- Urine and feces

- Nasal and oral swabs
- Vibrissae (pulled)
- Skin, blubber, or muscle biopsies
- Weight and body measurements

In addition to samples, capture and restraint of animals may be conducted to carry out the following procedures:

- Injection of sedative
- Administration of drugs (intramuscular, subcutaneous, or topical)
- Attachment of instruments to hair or flippers, including flipper tagging
- Ultrasound

6 EFFECTS OF THE ACTION

“Effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR § 402.02).

This biological opinion relies on the best scientific and commercial information available. We try to note areas of uncertainty, or situations where data is not available. In analyzing the effects of the action, NMFS gives the benefit of the doubt to the listed species by minimizing the likelihood of false negative conclusions (concluding that adverse effects are not likely when such effects are, in fact, likely to occur).

We organize our effects analysis using a stressor identification – exposure – response – risk assessment framework for the proposed activities.

We conclude this section with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

NMFS identified and addressed all potential stressors; and considered all consequences of the proposed action, individually and cumulatively, in developing the analysis and conclusions in this opinion regarding the effects of the proposed action on ESA-listed species and designated critical habitat.

6.1 Project Stressors

Stressors are any physical, chemical or biological phenomena that can induce an adverse response. The effects section starts with identification of the stressors produced by the constituent parts of the proposed action.

Based on our review of the data available, the proposed activities may cause these primary stressors:

1. sound field produced by impulsive noise sources such as impact pile driving
2. sound fields produced by continuous noise sources such as: dredging, screeding, trenching, vessels, aircraft, and vibratory pile driving operations;
3. risk of vessels striking marine mammals;
4. seafloor disturbance from pile driving, dredging, screeding, trenching, and pipelaying activities and placement of equipment or anchors;
5. pollution from authorized and unauthorized spills;
6. introduction of invasive species from vessels;
7. entanglement and ingestion of trash and debris.

All potential stressors from the proposed action were considered, individually and cumulatively, in developing the analysis and conclusions in this opinion regarding the effects of the proposed action on ESA-listed species that are likely to be adversely affected (bowhead whales, Cook Inlet beluga whales, humpback whales (Mexico and WNP DPS), fin whales, sperm whales, Arctic ringed seals, and Beringia DPS bearded seals).

6.2 Exposure and Response Analysis

As discussed in the *Approach to the Assessment* section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

For our exposure analyses, NMFS generally considers an action agency's estimates of the number of marine mammals that might be "taken" over the duration of the proposed action. AGDC provided a five-year quantitative exposure analysis to NMFS Permits Division with its LOA and IHA applications. Based on these initial qualitative and quantitative analyses, NMFS Permits Division calculated the exposure and MMPA "take" estimates for the five years of the Cook Inlet activities, and one year of activities in Prudhoe Bay.

Following the exposure analysis is the response analysis. The response analysis determines how listed species are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. Our assessments try to detect the probability of lethal responses, physical damage, physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

Possible responses by ESA-listed marine mammals to project activities in this analysis are:

- Threshold shifts

- Auditory interference (masking)
- Behavioral responses
- Non-auditory physical or physiological effects

Responses from ESA-listed species to project activities are discussed for each stressor.

As discussed in Section 2.1.2 above, the NMFS Permits Division and FERC proposed mitigation measures should avoid or minimize exposure of listed species to stressors.

6.2.1 Threshold Shifts

Exposure of marine mammals to very loud noise can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Temporary threshold shift (TTS) is a temporary hearing change, and its severity is dependent upon the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). TTSs can last minutes to days. Full recovery is expected, and this condition is not considered a physical injury. At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur. When PTS occurs, auditory sensitivity is unrecoverable (i.e., permanent hearing loss). The effect of noise exposure generally depends on a number of factors relating to the physical and spectral characteristics of the sound (e.g., the intensity, peak pressure, frequency, duration, duty cycle), and relating to the animal under consideration (e.g., hearing sensitivity, age, gender, behavioral status, prior exposures). Both TTS and PTS can result from a single pulse or from accumulated effects of multiple pulses from an impulsive sound source (i.e., impact pile or pipe driving) or from accumulated effects of non-pulsed sound from a continuous sound source (i.e., vibratory pile driving). In the case of exposure to multiple pulses, each pulse need not be as loud as a single pulse to have the same accumulated effect.

As it is a permanent auditory injury, the onset of PTS may be considered an example of “Level A harassment” as defined in the MMPA. TTS is by definition recoverable rather than permanent, and has historically has been treated as “Level B harassment” under the MMPA. Behavioral effects may also constitute Level B harassment, and are expected to occur at even lower noise levels than would generate TTS.

6.2.2 Auditory Interference (masking)

Auditory interference, or masking, occurs when an interfering noise is similar in frequency and loudness to (or louder than) the auditory signal received by an animal while it is processing echolocation signals or listening for acoustic information from other animals (Francis and Barber 2013). Masking can interfere with an animal’s ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Francis and Barber 2013).

Critical ratios, a measure of the relative ability of an animal to extract signals from noise, have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003) and bottlenose dolphins (Johnson 1967). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low frequency cetaceans, including calculating the cumulative impact of multiple noise sources. They found that two commercial vessels passing through a North Atlantic right whale's optimal communication decreased the size of that space by 84 percent. Subsequent research for the same species and location estimated that an average of 63 to 67 percent of North Atlantic right whale's communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase in ambient noise (Hatch et al. 2012).

Vocal changes in response to anthropogenic noise can occur across sounds produced by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying. Vocalizations may also change in response to variation in the natural acoustic environment (e.g., from variation in sea surface motion) (Dunlop et al. 2014).

In the presence of low frequency active sonar, humpback whales have been observed to increase the length of their songs (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been observed to increase the frequency and amplitude (intensity) (Parks 2009) of their calls while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007). In contrast, both sperm and pilot whales potentially ceased sound production during experimental sound exposure (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Phocids (ringed and bearded seals) and bowhead whales have good low-frequency hearing; thus, it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as those from vessel noise or pile driving (Gordon et al. 2003).

Evidence suggests that at least some marine mammals have the ability to acoustically identify predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for responding to all killer whale calls. Auditory masking may prevent marine mammals from responding to the acoustic cues produced by their predators. The effects of auditory masking on the predator-prey relationship depends on the duration of the masking and the likelihood of encountering a predator.

6.2.3 Behavior Response

NMFS expects the majority of ESA-listed species responses to the proposed activities will occur in the form of behavioral response. Marine mammals may exhibit a variety of behavioral changes in response to underwater sound and the general presence of project activities and equipment, which can be generally summarized as:

- Modifying or stopping vocalizations
- Changing from one behavioral state to another
- Movement out of feeding, breeding, or migratory areas

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995). More recent reviews (Ellison et al. 2012; Nowacek et al. 2007; Southall et al. 2009; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see following section). Responses can overlap; for example, a flight response is likely to be coupled with an increased respiration rate. Differential responses are expected among and within species since hearing ranges vary across species and individuals, the behavioral ecology of individual species is unlikely to completely overlap, and individuals of the same species may react differently to the same, or similar, stressor.

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Richardson et al. 1995; Southall et al. 2007). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 μ Pa root mean square (rms). Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 μ Pa.

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall (2007). Blackwell et al. (2004b) observed that ringed seals exhibited little or no reaction to drilling noise with mean underwater levels of 157 dB re 1 μ Pa rms and in air levels of 112 dB re 20 μ Pa, suggesting the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulsive source at levels of 165 to 170 dB re 1 μ Pa (Finneran et al. 2003).

Experimentally, (Götz and Janik 2011) tested underwater responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a non-startling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment did not react or habituate during the exposure period. The results of this study highlight the importance of the characteristics of

the acoustic signal in an animal's habituation.

In cases where whale or seal response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), effects are not likely to be significant at the population level, but could rise to the level of harassment of individuals.

Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012). This is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis and Barber 2013).

6.2.4 Non-Auditory Physical or Physiological Effects

Individuals exposed to noise can experience stress and distress, where stress is an adaptive response that does not normally place an animal at risk, and distress is a stress response resulting in a biological consequence to the individual. Both stress and distress can affect survival and productivity (Cowan and Curry 2002; Cowan and Curry 2008; Curry and Edwards 1998; Herráez et al. 2007). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and Hall 1997; Hunt et al. 2006; Romero et al. 2008; St. Aubin et al. 1996).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. For example, various efforts have investigated the impact of vessels on marine mammals (both whale-watching and general vessel traffic noise) and demonstrated that impacts do occur (Bain et al. 2006; Erbe 2002; Noren et al. 2009; Pirotta et al. 2015; Williams et al. 2002). In an analysis of energy costs to killer whales, Williams and Noren (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, suggesting that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to their previous level within 24 hrs after the resumption of shipping traffic. Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011). In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight and Swaddle 2011).

If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004).

Whales and seals use hearing as a primary way to gather information about their environment and for communication; therefore, we assume that limiting these abilities is stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006). Therefore,

exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006; NRC 2003).

We expect that project activities may result in animals' experiencing masking of communications, Level A and Level B acoustic harassment, and exhibiting behavioral responses. Therefore, we expect ESA-listed whales and seals may experience stress responses. If whale and seals are not displaced and remain in a stressful environment (i.e., within the behavioral harassment zone), we expect the stress response will dissipate shortly after the individual leaves the area or after the cessation of the acoustic stressor.

6.3 Stressors Likely to Adversely Affect ESA-Listed Species

6.3.1 Major Noise Sources

As discussed in Section 2, *Description of the Proposed Action*, FERC intends to authorize a wide variety of activities that will have acoustic effects within the action area (Table 1, Table 8, and Figure 1).

Major sources of noise include impact and vibratory pile driving of sheet and pipe piles in both Prudhoe Bay and Cook Inlet, and use of vessel thrusters during anchor handling by the pipelay vessel in Cook Inlet.

6.3.1.1 Acoustic Thresholds

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR 1871, 1872; January 11, 2005). NMFS recently developed comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary thresholds shifts (PTS and TTS) (83 FR 28824; June 21, 2018). NMFS is in the process of developing guidance for behavioral disruption (Level B harassment). However, until such guidance is available, NMFS uses the following conservative thresholds of underwater sound pressure levels,⁶ expressed in root mean square⁷ (rms), from broadband sounds that cause behavioral disturbance, and referred to as Level B harassment under section 3(18)(A)(ii) of the MMPA (16 U.S.C. § 1362(18)(A)(ii)):

- impulsive sound: 160 dB_{rms} re 1 μPa
- continuous sound: 120 dB_{rms} re 1 μPa

Under the PTS Technical Guidance, NMFS uses the following thresholds (Table 45) for underwater sounds that cause injury, referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (16 U.S.C. § 1362(18)(A)(i)) (NMFS 2018c). Different thresholds and auditory weighting functions are provided for different marine mammal hearing groups, which are

⁶ Sound pressure is the sound force per unit micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in acoustics is 1 μPa, and the units for underwater sound pressure levels are decibels (dB) re 1 μPa.

⁷ Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

defined in the Technical Guidance (NMFS 2018c). The generalized hearing range for each hearing group is in Table 44. The calculation of a Level A harassment threshold incorporates the duration the activity will occur (either by the total number of daily strikes or the amount time the duration will occur in a day), while calculation of a Level B harassment zone does not. As a result, sometimes the Level A harassment zones end up larger than the Level B harassment zones for the same activity. However, in order for a permanent threshold shift to occur any animal would have to stay in the zone at a particular distance for a duration of time to accumulate sufficient energy, for a permanent threshold shift to occur.

Table 44. Underwater marine mammal hearing groups (NMFS 2018c)

Hearing Group	ESA-listed marine mammals in the project area	Generalized hearing range ^a
Low-frequency (LF) cetaceans (Baleen whales)	bowhead whales, humpback whales	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales)	Cook Inlet beluga whales	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises)	None	275 Hz to 160 kHz
Phocid pinnipeds (PW) (true seals)	ringed and bearded seals	50 Hz to 86 kHz
Otariid pinnipeds (OW) (sea lions and fur seals)	None	60 Hz to 39 kHz
^a Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 db threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).		

These acoustic thresholds are presented using dual metrics of cumulative sound exposure level (L_E) and peak sound level (PK) for impulsive sounds and L_E for non-impulsive sounds.

Level A harassment radii can be calculated using the optional user spreadsheet⁸ associated with NMFS Acoustic Guidance, or through modeling.

⁸ The Optional User Spreadsheet can be downloaded from the following website:
<http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm>

Table 45. PTS onset acoustic thresholds for Level A harassment (NMFS 2018c)

Hearing Group	PTS Onset Acoustic Thresholds* (Received Level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	<i>L</i> _{pk,flat} : 219 dB <i>LE</i> ,LF,24h: 183 dB	<i>LE</i> ,LF,24h: 199 dB
Mid-Frequency (MF) Cetaceans	<i>L</i> _{pk,flat} : 230 dB <i>LE</i> ,MF,24h: 185 dB	<i>LE</i> ,MF,24h: 198 dB
High-Frequency (HF) Cetaceans	<i>L</i> _{pk,flat} : 202 dB <i>LE</i> ,HF,24h: 155 dB	<i>LE</i> ,HF,24h: 173 dB
Phocid Pinnipeds (PW) (Underwater)	<i>L</i> _{pk,flat} : 218 dB <i>LE</i> ,PW,24h: 185 dB	<i>LE</i> ,PW,24h: 201 dB
Otariid Pinnipeds (OW) (Underwater)	<i>L</i> _{pk,flat} : 232 dB <i>LE</i> ,OW,24h: 203 dB	<i>LE</i> ,OW,24h: 219 dB
<p>* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.</p> <p><u>Note:</u> Peak sound pressure (<i>L</i>_{pk}) has a reference value of 1 μPa, and cumulative sound exposure level (<i>LE</i>) has a reference value of 1μPa²s. The subscript “flat” is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.</p>		

In addition, NMFS uses the following thresholds for in-air sound pressure levels from broadband sounds that cause Level B behavioral disturbance under section 3(18)(A)(ii) of the MMPA (16 U.S.C § 1362(18)(A)(ii)):

- 100 dB re 20μPa_{rms} for non-harbor seal pinnipeds

The MMPA defines “harassment” as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment]” (16 U.S.C. § 1362(18)(A)).

While the ESA does not define “harass,” NMFS issued guidance interpreting the term “harass” under the ESA as to: “create the likelihood of injury to wildlife by annoying it to such an extent

as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering” (Wieting 2016). For purposes of this consultation, we consider any exposure to Level B behavioral disturbance sound thresholds to constitute harassment under the ESA.

Prudhoe Bay Noise Sources and Exposure Estimate

There have been numerous studies characterizing underwater sounds and propagation in the Beaufort Sea over the last 30 years associated with oil and gas development. Greene (1983) measured sounds during construction of Seal Island. He found that noise from construction above 1,000 Hz was not detectable above ambient at 2.2 miles (3.6 km) from the Seal Island construction site. During early island construction when ice was being cut and moved, noise from this construction operation at frequencies < 500 Hz was detectable to 0.5 miles (0.8 km), and a single tone near 60 Hz was detectable up to 1 mile (1.6 km). During late island construction, low-frequency sounds were detectable underwater out to a distance of 0.5 miles (0.8 km).

Greene et al. (2008) conducted studies of underwater sound, airborne sound, and iceborne vibrations associated with construction of Northstar Island (~39 ft, 12 m depth). Under ice vibratory pile driving was found to have a low frequency tone of 25 Hz with an underwater transmission loss coefficient of 39.1; the broadband transmission loss coefficient was 18.4. The measured levels of the ditchwitch and backhoe were 122 dB and 125 dB, respectively at 100 m (328 ft) with the center frequency at 20 Hz for the ditchwitch and 160 Hz for the backhoe. The transmission loss coefficient was 22.4 for the ditchwitch and 26.4 for the backhoe. They report broadband sounds from these activities diminished to the median background level of 77–116 dB (10-10,000 Hz range) at distances between 0.62 and 3.1 miles (1 and 5 km). The bulldozer used in shallow water was measured at 114 dB at 100 m (328 ft).

As described in Section 2, the pile sizes requiring the use of an impact driver for the Prudhoe Bay component of this project include 11.5-in H pile, 14-in H piles, and 48-in pipe piles. Source levels for these piles were adopted from California Department of Transportation (CalTrans 2015) who compiled measured SPL data from impact pile driving for pile sizes ranging in diameter from 12 to 96 in. The U.S. Department of Transportation Construction Noise Model Handbook (USDOT 2006) provides a summary of equipment with measured maximum airborne sound levels at 50 ft (15 m). The handbook reports an airborne level of 101 dBA⁹ at 50 ft (15 m) for impact pile driving.

West Dock modification activities include impact pile driving, vibratory pile driving, screeding, trenching, and grading. Sound sources associated with the planned activities will generate relatively low frequency (<1,000 Hz) sound and will be located in shallow waters at West Dock (<14 ft, <4 m). Based on results from these other measurements, project noise will likely

⁹The method commonly used to quantify airborne sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects that human hearing is less sensitive at low frequencies and extremely high frequencies than at mid-range frequencies. This is called A-weighting, and the measured level is called the A-weighted sound level (dBA). Sound levels to assess potential noise impacts on terrestrial wildlife, airborne or underwater, are not weighted and measure the entire frequency range of interest, unless specified by an agency.

diminish to background levels within less than 3.1 miles (5 km). Table 46 summarizes the stressors, sound source levels, frequencies at which the equipment operates, and the associated reference. Table 47 outlines the parameters used to calculate the acoustic thresholds and the Level A and B zones for each stressor. Table 48 provides the area of ensonification for each Level A and B zone. Figure 71 provides a visual representation of the Level A and B zones in the project area.

Table 46. Summary of noise sources in the Prudhoe Bay portion of the Alaska LNG project

Activity	Airborne Sound Level (dB re 20 μ Pa)	Underwater Sound Level (dB re 1 μ Pa)	Frequency	Reference
Impact 11.5-in H piles	101 dBA at 15 m	183 dB rms at 10 m 200 dB peak at 10 m 170 dB SEL at 10 m (water depth 5 m)	Range: 100-4,000 Hz Concentration: 125 Hz	Airborne: USDOT 2006 Underwater: Caltrans 2015
Impact 14-in H piles	101 dBA at 15 m	187 ^a dB rms at 10 m 208 dB peak at 10 m 177 dB SEL at 10 m (water depth 6 m)	Range: 100-4,000 Hz Concentration: 125 Hz	Airborne: USDOT 2006 Underwater: Caltrans 2015 Illingworth and Rodkin 2007
Vibratory 14-in H piles	101 dBA at 15 m	150 dB rms at 10 m 160 dB peak at 10 m 150 dB SEL at 10 m (water depth 5 m)	Range: 100-4,000 Hz Concentration: 125 Hz	Airborne: USDOT 2006 Underwater: Caltrans 2015
Impact 48-in pipe piles	101 dBA at 15 m	195 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m (water depth 5 m)	Range: 100-10,000 Hz Concentration: 24-25 Hz	Airborne: USDOT 2006 Underwater: Caltrans 2015
Vibratory sheet piles 19.69 & 25 in	81 dB at 100 m	160 dB rms at 10 m 175 dB peak at 10 m 160 dB SEL at 10 m (water depth 15 m)	Range: 10-10,000 Hz Concentration: 24-25 Hz	Caltrans 2015
Ice trenchers (bulldozer)	64.7 dB at 100 m	114 dB rms at 100 m	Range: 10-8,000 Hz Concentration: 31-400 Hz	Greene et al. 2008
Screeding/Grading Excavators (backhoe)	78 dBA at 15 m	125 dB rms at 100 m	Screeding Range: 10-10,000 Hz Concentration: 10-2,000 Hz Grading Excavators Range: 10-8,000 Hz Concentration: 31-400 Hz	Airborne: USDOT 2006 Underwater: Greene et al. 2008

Activity	Airborne Sound Level (dB re 20 μPa)	Underwater Sound Level (dB re 1 μPa)	Frequency	Reference
General vessel operations	N/A	145-175 dB rms	10 Hz – 1,500 Hz	Richardson et al. 1995; Blackwell and Greene 2003; Ireland and Bisson 2016
^a 187 dB rms was from (Illingworth & Rodkin 2007)				

Table 47. Summary of stressors, associated sound source levels, parameters used, and calculated distances to Level A and B in Prudhoe Bay. Only those activities for which MMPA take authorization was requested are shown.

Activity	User Spreadsheet Parameters								Underwater Level B (m)		Underwater Level A (m)						Airborne Level B (m)	
	Underwater Sound Level (dB re 1 µPa)	Source Level at 1 meter	TL	Number of piles per day	Duration to drive single pile (min)	Number of strikes per pile	Source Velocity (m/s)	Unweighted SEL (10 log duration)	All Marine Mammals		Low Frequency Cetaceans		Phocids			Pinnipeds		
									Impulsive @ 160dB	Non-Impulsive @ 120 dB	Impulsive @ 160dB		Non-Impulsive @ 120 dB		Impulsive @ 160dB	Non-Impulsive @ 120 dB	Sound Level (dB re 20 µPa)	Threshold Distance @ 100dB
											Peak 219 dB	SEL 183dB	SEL 199dB	Peak 218dB				
11.5-in H piles Impact pile driving	183 dB rms at 10 m 200 dB peak at 10 m 170 dB SEL at 10 m	198	15	26.09	-	1,000	-	214	341	-	<1	1,194	-	1	639	-	101 dBA at 15 m	16.8
14-in H piles Impact pile driving	1871 dB rms at 10 m 208 dB peak at 10 m 177 dB SEL at 10 m	202	15	4	-	1,000	-	213	631	-	2	1,002	-	2	536	-	101 dBA at 15 m	16.8
14-in H piles Vibratory pile driving	150 dB rms at 10 m 160 dB peak at 10 m 150 dB SEL at 10 m	165	15	8	15	-	-	-	-	1,000	-	-	2	-	-	1	101 dBA at 15 m	16.8
48-in pipe piles Impact pile driving	195 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m	210	15	1.25	-	1,000	-	215	2,154	-	3	1,575	-	3	843	-	101 dBA at 15 m	16.8
19.69 & 25 in sheet piles Vibratory pile driving	160 dB rms at 10 m 175 dB peak at 10 m 160 dB SEL 10 m	175	15	15.24	18.9	-	-	-	-	4,642	-	-	17	-	-	10	81 dB at 100 m	11.2
Ice trenchers (bulldozer) ^a	114 dB rms at 100 m	144	15	-	-	-	0.51	-	-	40	-	-	-	-	-	-	64.7 dB at 100 m	1.8
Screeding/Grading Excavators ^c (backhoe)	125 dB rms at 100 m	155	15	-	-	-	0.51	-	-	215	-	-	-	-	-	-	78 dBA at 15 m	1.2

^aTake is not anticipated or authorized for these activities, therefore, they are not included in the exposure estimates below.

Table 48. Area of Level A and B ensounded zones for Prudhoe Bay

Activity	Level B (km ²)	Level A (km ²)	
	All Marine Mammals	Low Frequency Cetaceans	Phocids
11.5-in H piles Impact pile driving	0.37	4.48	1.28
14-in H piles Impact pile driving	1.25	3.15	0.9
14-in H piles Vibratory pile driving	3.14	0	0
48-in pipe piles Impact pile driving	14.58	7.8	2.23
19.69 & 25 in sheet piles Vibratory pile driving	67.68	0	0

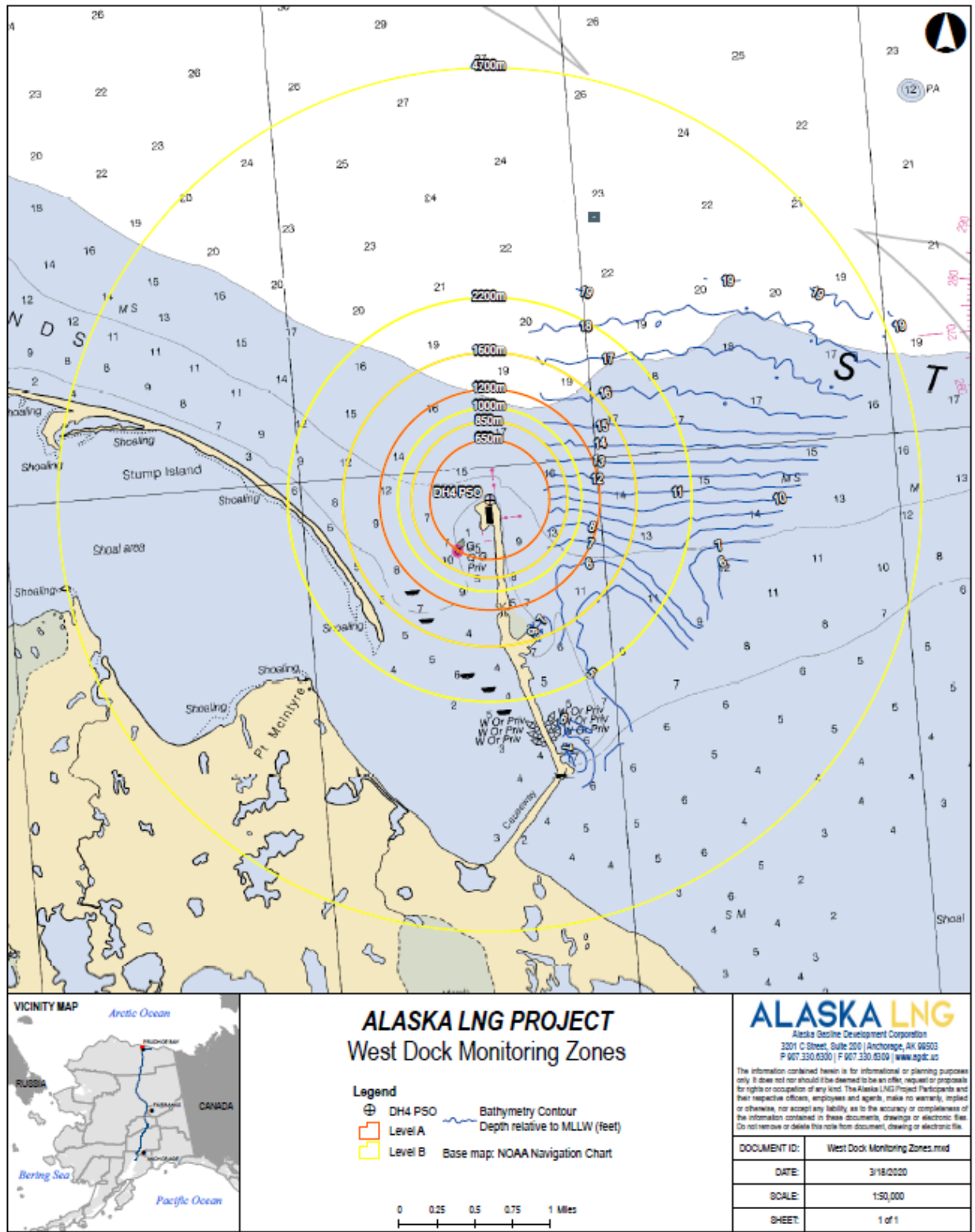


Figure 71. Prudhoe Bay Level A and Level B zones

Prudhoe Bay Exposure Estimates

It is difficult to estimate the number of individuals by age or gender that may be affected by the project; however, there is density information available on the number of individuals across all age classes and gender for each ESA-listed species. To determine the number of marine mammals expected to be exposed at any given time during the life of the project, densities by season were identified for each ESA-listed species. Table 49 summarizes densities for ESA-listed marine mammals. Details on the studies and information used to derive these densities are available in Section 4.

Exposure estimates were calculated by multiplying the season-specific density estimates for each species (Table 49) expected to be present in project area by the area ensouffied to the Level A and B thresholds (Table 48), multiplied by the number of days it will take to complete each activity (Table 50). Considering the work is expected to be completed from July through October, the highest densities during these months were used to estimate exposure (these are the bolded numbers in Table 49). If pile driving activities are not completed in the open water season, AGDC has proposed a contingency period in late February through April of the following year; however, there was no adjustment to the exposure estimate because it is unknown the duration of pile driving that would occur during this contingency period. We did not adjust our exposure estimate to account for spring-based work for the following reasons: 1) the number of ice seals that would be affected by work in the spring is far lower in regions dominated by bottomfast ice; 2) the majority of the project area in Prudhoe Bay is of 3m depth or less, and will be dominated by bottomfast ice in Feb-April; 3) far fewer animals will be exposed to spring-based work because shorefast ice will be stationary, and only those seals that have breathing holes or lairs near the project will be exposed; and 4) animals hauled out on ice or in their lairs will not be harassed by sound due to the insulative properties of snow and lack of transmission from the water back into the atmosphere. For these reasons, applying the exposure estimate that assumes all work was completed during summer provides us with a conservative exposure estimates should some of the work need to occur in the late winter and early spring.

Table 51 outlines the estimated Level A and B exposure for the project. Even though there is a calculated exposure estimate for bowhead whales, it is unlikely that a bowhead would occur in such shallow waters (approximately 19 ft in depth) at the outer edge of the Level A threshold for LF cetaceans. Therefore, no Level A take is expected for bowhead whales.

Table 49. Marine mammal densities in the Prudhoe Bay area by season

Species	Seasonal Average Density (individuals/square kilometer)			
	Spring (Apr – June)	Summer (Jul – Aug)	Fall (Sept – Oct)	Winter (Nov – Mar)
Bowhead whale ^a	0	0.005	0.017	0
Ringed seal ^b	0.548	0.274	0.274	0.509
Bearded seal ^c	0.003	0.047	0.047	0.003

Note: Bolded densities were used to estimate exposure since project activities are expected to occur in the open water season (July through October).

^a Calculated densities in ASAMM Survey Block 1, 2011-2018

^b Spring values from Moulton et al, 2005, summer / fall density estimated at 50 percent of spring density, winter densities based on reported ice structure density and an estimate of 2.85 structures / seal.

^c Spring density based on observations at Northstar, summer / fall densities based on reported relative bearded seal rates of occurrence are based on 17 percent of reported ringed seal density.

Table 50. Calculated durations for installation and removal of piles below MLLW in Prudhoe Bay

Pile Type	Number of Piles by Size					Linear Length (ft) Below MLLW	Number of Days (rounded up to whole days)
	Impact Hammer			Vibratory Hammer			
	11-5-in H Pile ^a	14-in H Pile ^a	48-in Pipe Pile ^b	14-in H Pile ^c	Sheet Pile ^a		
Dock head 4							
Sheet pile ^a	0	0	0	0	422	879.17	36
Anchor pile (H-pile) ^a	212	0	0	0	0	203.17	9
Mooring dolphins ^b	0	0	12	0	0	NA	10
Temporary spud piles ^c	0	0	0	48	0	NA	12
South Bridge Abutment							
Dock face (sheet pile) ^a	0	0	0	0	350	574.29	23
Tailwall (sheet pile) ^a	0	0	0	0	345	566.09	23
Anchor pile (H-pile) ^{a,b}	0	4	0	0	0	4.67	1
North Bridge Abutment							
Dock face (sheet pile) ^a	0	0	0	0	353	579.21	24
Tailwall (sheet pile) ^a	0	0	0	0	256	420.05	17
Anchor pile (H-pile) ^{a,c}	0	4	0	0	0	3.83	1
Barge Bridge							
Mooring dolphins ^b	0	0	4	0	0	NA ^d	4
Temporary spud piles ^c	0	0	0	16	0	NA ^d	4
Total Number of Days							164
<p>^a Durations (days of pile driving) based on an expected production rate of 25 linear (horizontal) ft of piles per day rounded up to the next whole number of days.</p> <p>^b Durations (days of pile driving) based on an expected production rate of 1.25 piles per day rounded up to the next whole number of days; actual duration dependent on weather, substrate, and equipment.</p> <p>^c Four temporary spuds (14-in steel H piles) are installed for each mooring dolphin (48-in pile), the mooring dolphin is installed, and then the 4 spuds are extracted. The assumed production rate for mooring dolphins is 1.25/day. Installation of 4 spuds takes 1 hour and extraction takes 1 hour; we assume 4 spuds would be installed and removed per day.</p> <p>^d NA is not applicable – horizontal length not utilized in duration calculations.</p>							

AGDC estimated the number of days it would take for each activity to be completed, for a total of 164 days (Table 50); however, there are only 123 calendar days in the months of July through October when the work is expected to occur. AGDC was not able to identify what activities will occur in the same day (AGDC has indicated that no two hammers will operate at the same time), but the 164 days overestimates the exposure estimate. Therefore, NMFS determined a

conservative estimated number of days that work would actually occur and applied that proportion to the total exposure estimate to calculate a more accurate estimate.

NMFS started with the 123 calendar days available for work in the months of July through October and subtracted 10 days of non-working days during the whaling season giving a total of 113 days. (The whaling season is typically 21 days, however, if the whaling season ends early as it sometimes does, AGDC would be able to start work.) Then NMFS accounted for the fact that AGDC has indicated that they will only be working 6 days a week. This equals 97 working days. AGDC has also proposed a contingency period in late February through April if all the work cannot be completed in July through October. Therefore, we took the 61 calendar days in March and April, applied the 6 working days a week, which leaves 52 possible working days. It is not expected that AGDC would need the entire 52 contingency days to complete the work, so NMFS determined adding half of these days to the number of working calendar days (from July through October, 97 calendar days) for the project would be more realistic. The resulting number of working calendar days estimated for the project, including a contingency period in late February through April, is 123 days (which coincidentally is the same number of calendar days in July through October):

$$\begin{aligned} & [(123 - 10) * (6/7)] + [(61 * 6/7) / 2] \\ & [113 * 0.86] + [(61 * 0.86) / 2] \\ & 97 + 26 = 123 \end{aligned}$$

This is a 25 percent reduction in the number of days AGDC used in their exposure estimate. Therefore, the take estimates were reduced by 25 percent (Table 51).

Table 51. Estimated Level A and B exposures by pile type and species

Activity	Level B			Level A		
	Bowhead whale	Ringed seal	Bearded seal	Bowhead whale	Ringed seal	Bearded seal
DH4						
Sheet pile	41.65	668.04	113.57	0	0.01	0
Anchor pile (11.5-in H-pile)	0.06	0.90	0.15	0.69	11.05	1.88
Mooring dolphins (48-in pipe pile)	2.49	39.98	6.80	1.33	21.37	3.63
Spud piles (14-in H pile pile)	0.64	10.34	1.76	0	0	0
South Bridge Abutment						
Dock face (sheet pile)	26.61	426.80	72.56	0	0.01	0
Tailwall (sheet pile)	26.61	426.80	72.56	0	0.01	0
Anchor pile (14-in H pile)	0.02	0.34	0.06	0.05	0.86	0.15
North Bridge Abutment						
Dock face (sheet pile)	27.76	445.36	75.71	0	0.01	0
Tailwall (sheet pile)	19.67	315.46	53.63	0	0	0
Anchor pile (14-in H pile)	0.02	0.34	0.06	0.05	0.86	0.15
Barge Bridge						
Mooring dolphins (48-in pipe pile)	1	15.99	2.72	0.53	8.55	1.45
Spud piles (14-in H pile)	0.21	3.45	0.59	0	0	0
Total	146.74	2,353.8	400.15	2.65^b	42.73	7.26
25 percent Reduction in Exposure Estimate Total^{ac}	110	1,765	300	0^b	32	5

^aRounded up or down from the nearest 10th.

^bDue to the shallow waters (approximately 19 ft in depth) at the outer edge of the Level A threshold for LF cetaceans it is unlikely that a bowhead would be seen in such shallow of water, therefore, no Level A take is being authorized for bowhead whales.

^cAGDC estimated the number of days it would take for each activity to be completed, for a total of 164 days (Table 50), however, there are only a 123 days in the months of July through October when the work is expected to occur. Therefore creating an overestimate on exposure. NMFS calculated a reduction of 25 percent of the exposure estimate by taking into consideration 1) the number of calendar days during the anticipated work window 2) no working days during the whaling season 3) 6 working days a week 4) the contingency period of late February through April.

Cook Inlet Noise Sources and Exposure Estimates

Full details of the source noise levels, references, and parameters used to model in-water noise

propagation are provided in the AK LNG project Underwater Noise Propagation Modelling Report developed by SLR Consulting (Appendix A). Project construction scenarios with the potential for noise above the thresholds have been identified previously in the project petition for incidental take regulations (AGDC 2020b). The propagation modeling uses the scenarios and overall source levels (Table 52). For the quantitative noise model, source levels and spectra were adopted from Austin et al. (2016) and (Carr et al. 2006).

Table 52. Summary of noise sources in the Cook Inlet portion of the Alaska LNG Project.

Project Activity	Proxy Pile Type and Size Measured	Underwater Sound Level (dB re 1 μPa)	Reference
Impact Sheet Pile	Impact 24-in AZ sheet pile	190 dB rms at 10 m 205 dB peak at 10 m 180 dB SEL at 10 m (water depth 15 m)	Compiled by Illingworth & Rodkin (2007)
Impact 18-in and 24-in Piles	Impact 24-in steel pipe pile	194 dB rms at 10 m 207 dB peak at 10 m 178 dB SEL at 10 m (water depth 15 m)	Compiled by Illingworth & Rodkin (2007)
Impact 48-in steel pipe pile	Impact 48-in steel pipe pile	200 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m (water depth 18 m)	Austin et al. (2016)
Impact 60-in piles	Impact 60-in steel cast-in-steel-shell pile	195 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m (water depth 5 m)	Compiled by Illingworth & Rodkin (2007)
Vibratory Sheet Pile	Vibratory 24-in AZ sheet pile	160 dB rms at 10 m 175 dB peak at 10 m 160 dB SEL at 10 m (water depth 15 m)	Compiled by Illingworth & Rodkin (2007)
Vibratory All Size Piles	Vibratory 72-in steel pipe pile	170 dB rms at 10 m 183 dB peak at 10 m 170 dB SEL at 10 m (water depth 5 m)	Compiled by Illingworth & Rodkin (2007)
Anchor Handling	Dynamic Positioning	179 dB rms at 10 m 179 dB SEL at 10 m	Blackwell and Greene (2003)

The noise model predicted distances and areas of ensonification to the Level A SEL_{24hr} threshold assuming the following:

Impact Pile Driving:

- Actual pile driving occurs during 25 percent of a 12-hour day (3 hours).

- Number of strikes per hour of 1,560 (based on 26 beats per minute of typical impact hammer).
- 4,680 strikes per day (3 hours per day, 1560 strikes/hour)

Vibratory Pile Driving:

- Actual pile driving occurs during 40 percent of a 12-hour day (4.8 hours).

Anchor Handling:

- Anchor handling occurs during 25 percent of 24-hour day (6 hours).
- Vessel speed of 1.54 m per second or 3 kn.

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

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

The three common spreading models are cylindrical spreading for shallow water, or $10 \log R$; spherical spreading for deeper water, or $20 \log R$; and practical spreading, or $15 \log R$. Several projects have measured the TL associated with pile driving in Cook Inlet. At Port MacKenzie in Upper Cook Inlet, Blackwell and Greene (2005) measured levels associated with impact and vibratory hammer of 36-in steel pipe and report a TL of $17.5 \log R$ for impact driving and 21.8 to $28 \log R$ for vibratory driving. URS (2007) and Scientific Fishery Systems Inc. (2009) measured levels associated with impact and vibratory pile driving at the Port of Alaska and used $20 \log R$ to estimate distances to the NMFS thresholds, but did not characterize the TL. Illingworth & Rodkin (2013) measured levels from impact hammering of conductor pipe in Lower Cook Inlet and report a TL of $20.4 \log R$.

In shallow water noise propagation is highly dependent on the properties of the seafloor and the surface as well as the properties of the fluid. Parameters such as depth and the bottom properties can vary with distance from the source. There is a low-frequency cut-off related to the water depth, below which energy is transferred directly into the sea floor. Overall, the transmission loss in shallow water is a combination of cylindrical spreading effects, bottom interaction effects (absorption) at lower frequencies and scattering losses at high frequencies.

Pile driving noise was modelled as a single stationary, omni-directional point source in each of the three main construction areas (PLF [near Nikiski], Temporary MOF [near Nikiski], and Mainline MOF [near Beluga River]) for each pile and hammer type. Source spectral shape information for each noise source and location were used from other studies (provided in Section 6.2). All piling sources were assumed to be located midway down the water column. Noise associated with anchor handling during pipe laying is represented as a series of five points on a line along the route, assuming a depth midway in the water column.

Modelling for this assessment used the dBSea software package. The fluid parabolic equation

modelling algorithm has been used with 5 Padé terms to calculate the transmission loss between the source and the receiver at low frequencies (16 Hz up to 1 kHz). For higher frequencies (1 kHz up to 8kHz) the ray tracing model has been used with 1000 reflections for each ray.

The received noise levels for Cook Inlet throughout the project have been calculated following the procedure outlined below:

- One-third octave source spectral levels are obtained via reference spectral curves with subsequent corrections based on their corresponding overall source levels;
- Transmission loss is modelled at one-third octave band central frequencies along 100 radial paths at regular increments around each source location, out to the maximum range of the bathymetry data set or until constrained by land.
- The bathymetry variation of the vertical plane along each modelling path is obtained via interpolation of the bathymetry dataset which has 50m grid resolution;
- The one-third octave source levels and transmission loss are combined to obtain the received levels as a function of range, depth and frequency at 100m intervals; and
- The overall received levels are calculated at a 1-m depth resolution along each propagation path by summing all frequency band spectral levels.

The predicted distances to the thresholds and areas of ensonfication for pile driving and anchor handling are summarized in Table 53. In practice, the distances to the Level A thresholds are controlled by the cumulative SEL_{24hr} , so the distances to the Level A peak thresholds were not modeled. Figure 72 through Figure 75, display the Level A and B contours for each project activity in Cook Inlet.

It should be noted that typically the larger the pile the larger the source levels, however, this model took into consideration the water depth of each project location. The 60" pile are driven in much shallow waters (5 m or less) and therefore has a strong low-frequency cut off, while the 48" and 24" piles are driven in deeper water (> 15 m). Therefore the source levels and associated thresholds are higher for the 48" piles (Table 53).

Table 53. Summary of stressors, sound source levels, parameters, and calculated distances to Level A and B in Cook Inlet

Activity	Modeling Parameters			Level B		Level A			
	Underwater Sound Level (dB re 1 μ Pa)	Active hrs per 24 hr	Number of strikes per day	All Marine Mammals		Low Frequency Cetaceans		Mid Frequency Cetaceans	
				Modeled Distance (m)	Modeled Area (km ²)	Modeled Distance (m)	Modeled Area (km ²)	Modeled Distance (m)	Modeled Area (km ²)
Product Loading Facility									
48" pipe impact	200 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m	3	4,680	3,593	13.24	3,175	10.91	211	0.07
60" pipe impact	195 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m	3	4,680	2,254	6.39	3,175	10.91	211	0.07
Temporary MOF									
Sheet piles vibratory	160 dB rms at 10 m 175 dB peak at 10 m 160 dB SEL at 10 m	4.8	-	4,377	18.23	238	0.04	0	0
24" pipe impact	194 dB rms at 10 m 207 dB peak at 10 m 178 dB SEL at 10 m	3	4,680	2,271	3.91	1,639	2.14	238	0.02
48" pipe impact	200 dB rms at 10 m 210 dB peak at 10 m 185 dB SEL at 10 m	3	4,680	3,546	9.21	3,239	7.44	238	0.06
Pipe vibratory	170 dB rms at 10 m 183 dB peak at 10 m 170 dB SEL at 10 m	4.8	-	5,584	27.7	285	0.13	0	0
Mainline MOF									
Sheet piles vibratory	160 dB rms at 10 m 175 dB peak at 10 m 160 dB SEL at 10 m	4.8	-	3,179	14.75	262	0.06	0	0
Sheet piles impact	190 dB rms at 10 m 205 dB peak at 10 m 180 dB SEL at 10 m	3	4,680	764	1.13	1,161	2.37	248	0.06
Pipelaying									
Anchor Handling	179 dB rms at 10 m 179 dB SEL at 10 m	6	-	2,855	20.67	0	0	0	0

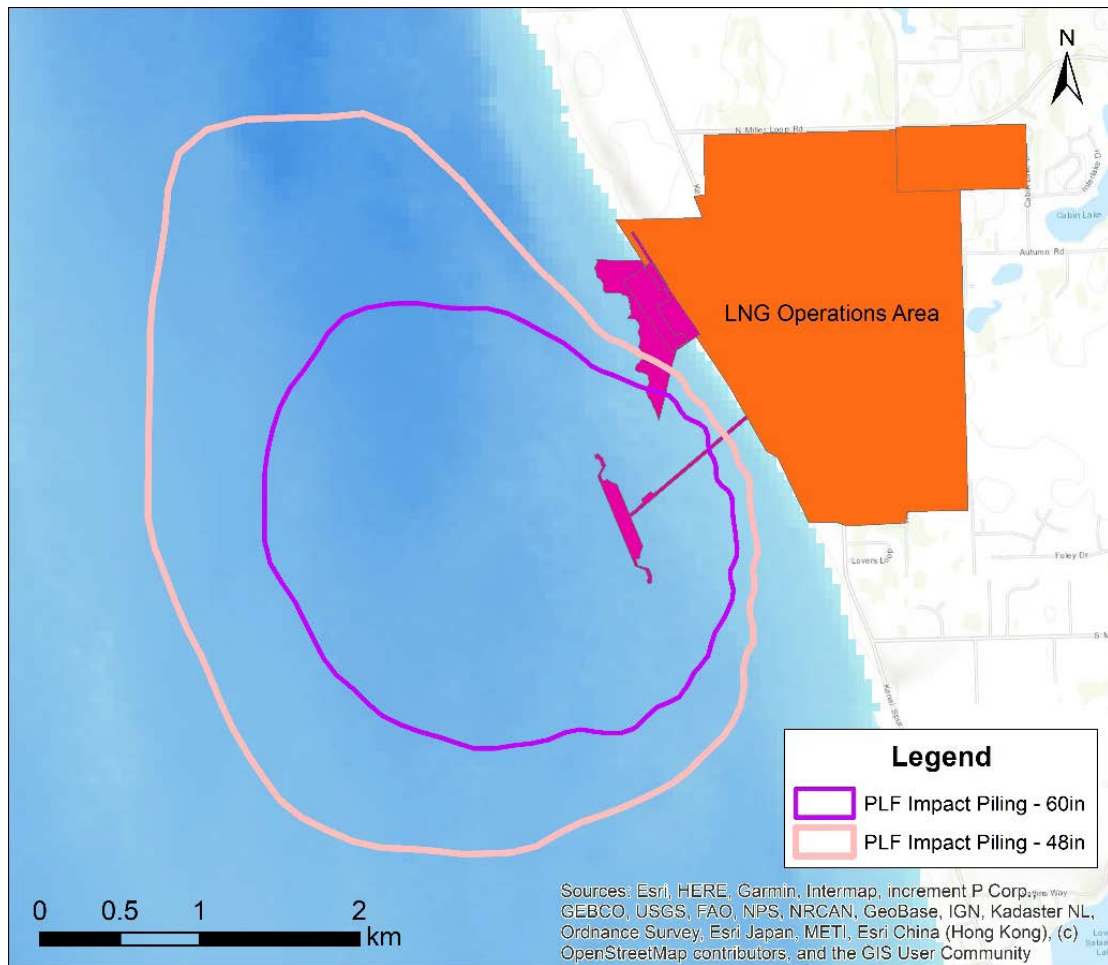


Figure 72. Predicted Level B contours for Cook Inlet product loading facility (PLF)

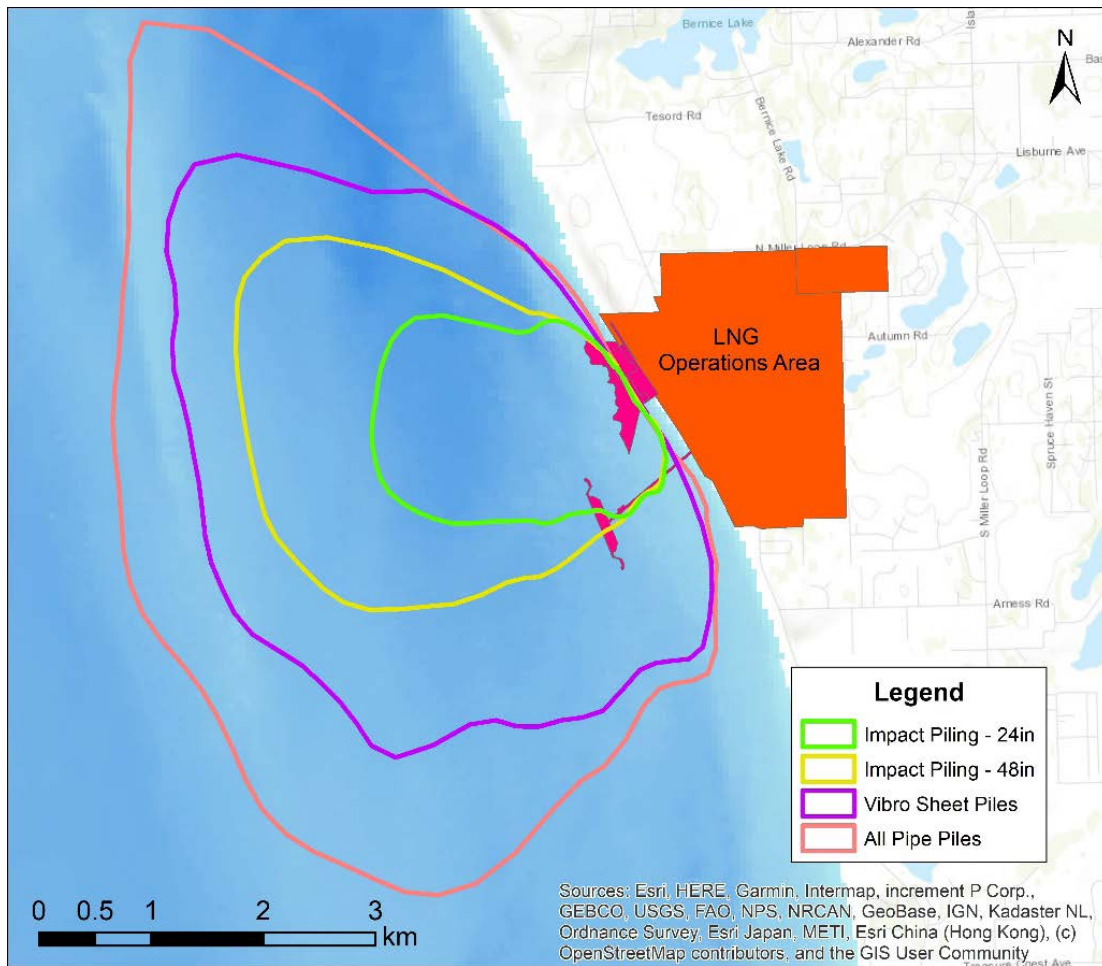


Figure 73. Predicted Level B contours for temporary Cook Inlet material offloading facility (MOF).

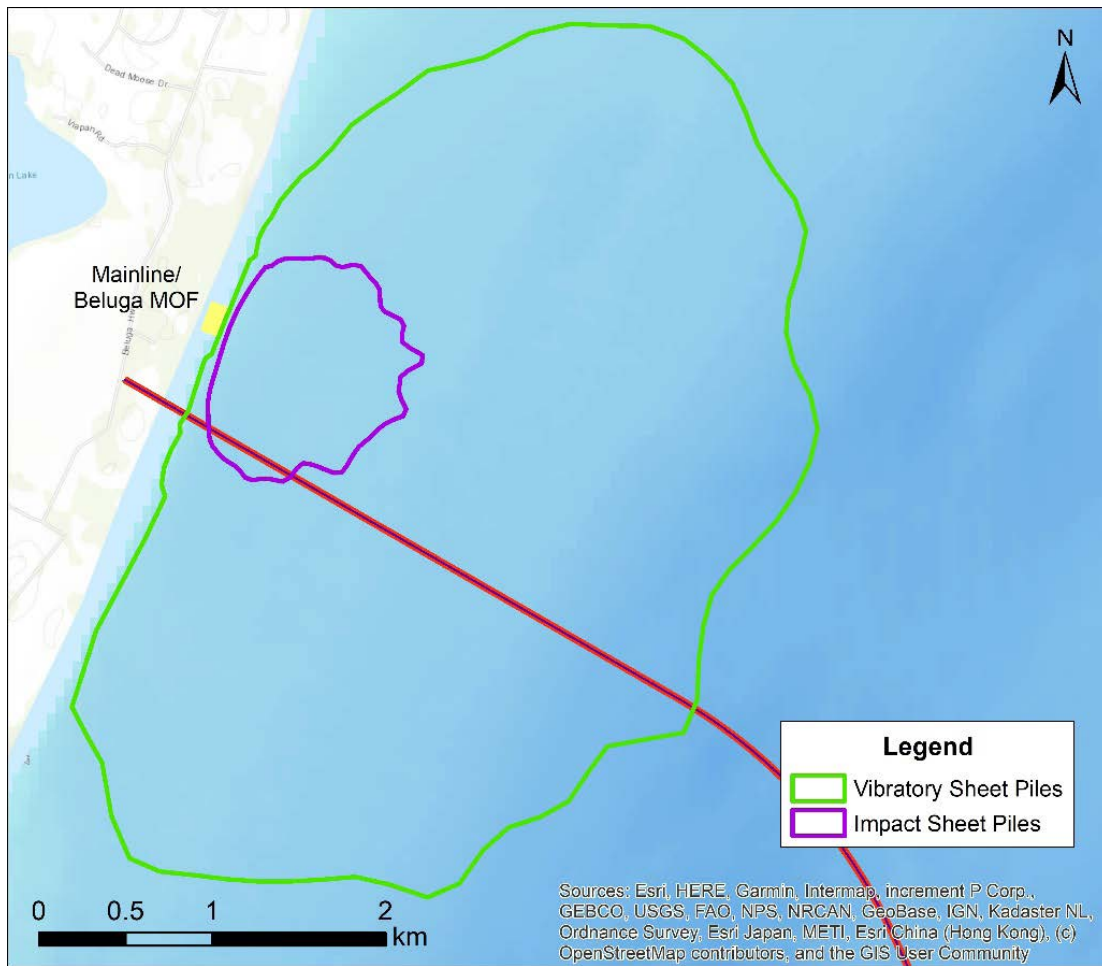


Figure 74. Predicted Level B contours for mainline material offloading facility (MOF) in Cook Inlet

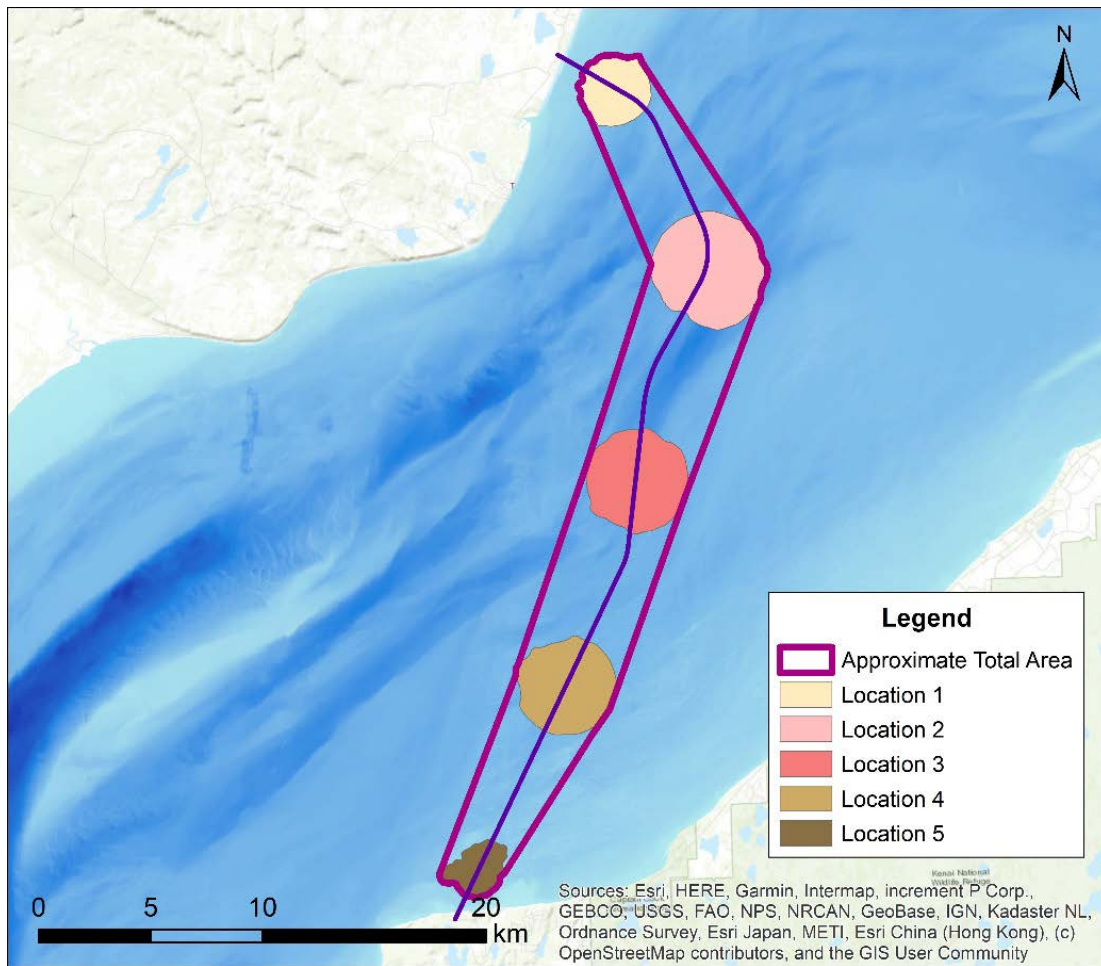


Figure 75. Predicted Level B contours for anchor handling in Cook Inlet

Other underwater sound sources expected during project construction include sound associated with dredging and trenching. These sound sources are mostly considered non-impulsive sounds and exceed the 120 dB rms disturbance threshold. We considered the dredge bucket striking the bottom as an impulsive sound, which did not exceed the 160 dB threshold for impulsive sound Level B harassment. There is no take being authorized for these activities, therefore, additional information on these activities is outlined in Section 6.3.1.2.

Cook Inlet Exposure Estimate

Similar to Prudhoe Bay, it is difficult to estimate the number of individuals by age or gender that maybe affected by the project; however, there is density information for each ESA-listed species. To determine the number of marine mammals expected to be exposed at any given time during the AK LNG construction, we multiplied the area of ensouification for the various Level A and B thresholds using the noise prediction model (Table 53) by the total duration in days for each season for each type of activity (Table 54 and Table 55) by the density (number of marine mammals/unit area).

Estimated durations in days per season, per facility, and by pile type and size are provided in

Table 55. The total number of structures (bents or quadropods) and needed days for driving the piles are based on an assumed period of April through October (months vary depending on location), a 12-hour work day, 25 percent of time spent with impact hammer operating, and 40 percent of time spent with vibratory hammer operating.

The total duration of anchor handling was calculated differently for the two seasons in which anchor handling will occur. In Season 3 the duration was calculated by assuming actual anchor handling would occur 25 percent of each day that anchor handling is ongoing. In Season 4 anchor handling duration was estimated by calculating the likely number of times individual anchors would be reset (based on resetting 12 anchors once per day and a lay rate of 2,500 ft per day) and assuming it takes 15 minutes to pull the anchor and 15 minutes to reset (Table 54). In Table 54, days equals the number of days the activity will occur, the percent of day is the percentage of day anchor handling would occur (25 percent of a 24-hour period), and the total 24-hour periods equals the number of days multiplied by the percent of day divided by 24 hours.

Table 54. Duration of anchor handling in total days for each season

Season	Activity	Anchors Reset	Reset Time (hours) ^a	Days	Percent of Day	Total 24-hour Periods
3	9 days mooring, 14 days pipe trenching	-	-	23	25	6
4	Pipeline days at rate of 2,500 ft per day	636	0.5	53	25	13

^aIncludes 15 minutes to pull an anchor and 15 minutes to reset (lower and then tension up).

Table 55. Duration of pile driving in total days for each facility and season

Season	Element	Number of Piles/Length of Sheet Pile Wall				Length of Sheet Pile Wall	Hammer	Months	Total Number of Structures	Number of Pile Driving Days per Structure	Total 24-hour Periods
		18-in	24-in	48-in	60-in						
Product Loading Facility											
3	E-W Access Trestle	-	-	-	33	-	Impact	April–June	11	2	6
3	E-W Access Trestle	-	-	-	40	-	Impact	June–August	10	2	5
3	Berth 1	-	-	20	-	-	Impact	April–May	4	2	2
3	Berth 2	-	-	20	-	-	Impact	April–May	4	2	2
3	N-S Access Trestle	-	-	40	-	-	Impact	May–June	8	2	4
4	E-W Access Trestle	-	-	-	28	-	Impact	April–May	7	2	4
4	Operations Platform	-	-	-	12	-	Impact	May–June	3	2	2
4	Breasting Dolphin Berth 1 & 2	-	-	8	-	-	Impact	April–May	2	2	1
4	Breasting Dolphin Berth 1 & 2	-	-	-	32	-	Impact	April–May	6	2	3
4	Mooring Dolphin	-	-	2	-	-	Impact	May	1	2	1
4	Mooring Dolphin	-	-	-	8	-	Impact	May	1	2	1
4	N-S Access Trestle	-	-	30	-	-	Impact	April–May	6	2	3
5	Mooring Dolphin	-	-	10	-	-	Impact	April–June	3	2	2
5	Mooring Dolphin	-	-	-	40	-	Impact	April–June	7	2	4
5	Catwalk	-	-	-	8	-	Impact	April–May	8	2	4
Temporary Material Offloading Facility											
1	MOF combi wall	-	-	-	35	-	Vibratory	July	1	10.75	5
1	MOF combi wall	-	-	-	-	1,075	Vibratory	July	1	10.75	5
1	MOF cell	36	-	-	-	-	Vibratory	July–October	1	27.54	12
1	MOF cell	-	-	-	-	2,454	Vibratory	July–October	1	27.54	11
2	MOF cell	30	-	-	-	-	Vibratory	April–June	1	26.97	11
2	MOF cell	-	-	-	-	2,447	Vibratory	April–June	1	26.97	11
2	MOF Ro-Ro Dolphin Quads	-	-	28	-	-	Impact	April–June	3.5	2	2
2	MOF Ro-Ro Dolphin Quads	-	7	-	-	-	Impact	April–June	3.5	2	2
Mainline Material Offloading Facility											
2	Mainline MOF sheet pile	-	-	-	-	670	Vibratory	April–May	1	6.7	3
2	Mainline MOF sheet pile	-	-	-	-	670	Impact	April–May	1	6.7	2

There have been no documented sightings of sperm whales in upper Cook Inlet. This species prefers foraging in deeper waters, and is frequently found in the GOA, around the Aleutian Islands, and in the southern Bering Sea. Thus, we do not expect sperm whales to be exposed to noise from pile driving in Cook Inlet.

The farthest north a fin whale has been documented in Cook Inlet was just south of Anchor Point (Figure 76). Therefore, NMFS assumes that it is unlikely that fin whales will be exposed to noise from pile driving.

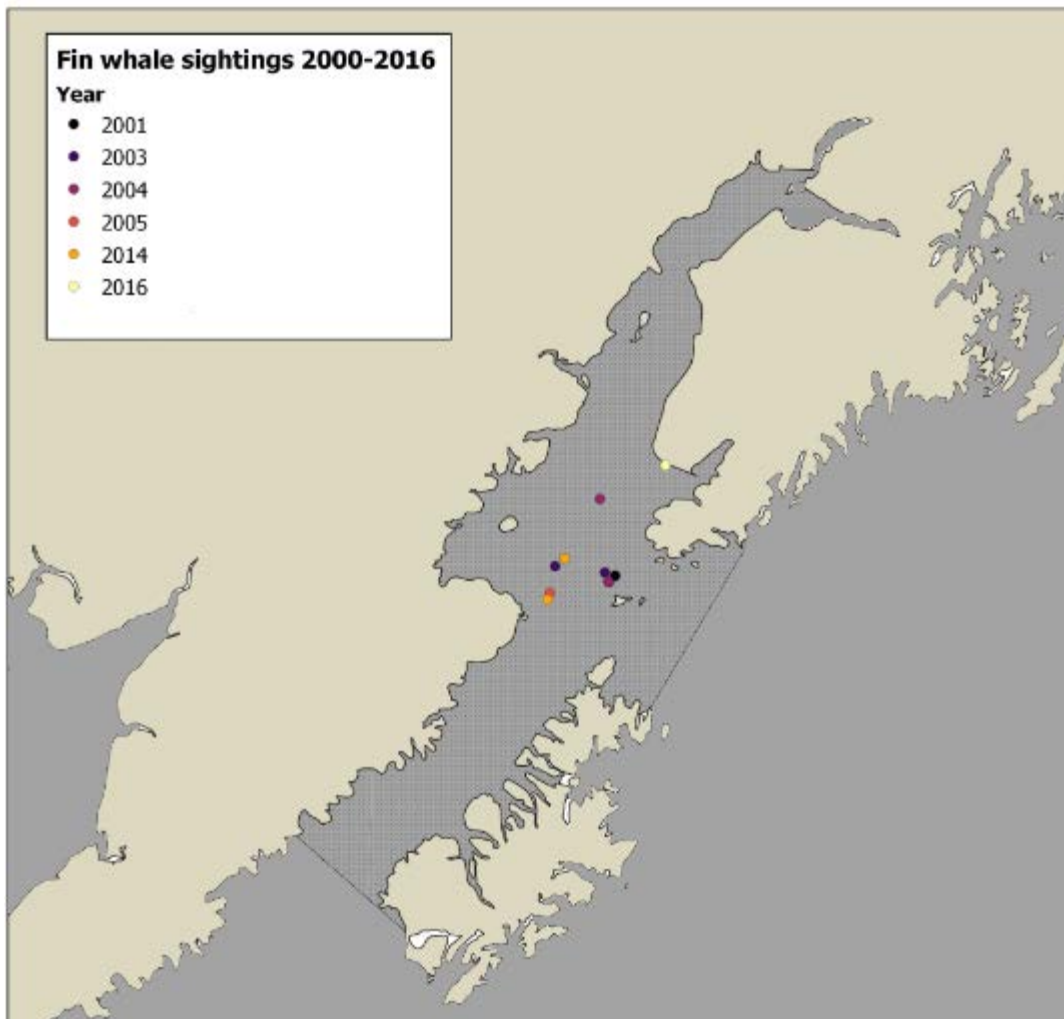


Figure 76. Fin whale sightings during aerial surveys for belugas from 2000-2016 (no fin whales were seen during 2000, 2002, 2006-2013).

The density for humpback whales was determined by using aerial survey data collected by NMFS in Cook Inlet between 2000 and 2018. To estimate the average densities of marine mammals, the total number of animals for each species for each year observed over the 15-year survey period was divided by the total area surveyed each year (Table 36). Based on this methodology, the humpback whale density used to calculate the exposure estimate is 0.00177 humpbacks per square kilometer.

Goetz et al. (2012) modeled aerial survey data collected by NMFS between 1993 and 2008 and developed 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 (which is the best available approach for determining humpback whale density). To develop a beluga density estimate associated with project components, the GIS files of the predicted ensonified area for both Level A and B associated with each location and pile type, size, and hammer was overlain with the GIS file of the 1-square-kilometer (0.4-square-mile) beluga density cells. The cells falling within each ensonified area were provided in an output spreadsheet, and an average cell density for each project component was calculated. Figure 77 shows the Goetz et al. (2012) distribution with project components. Table 56 shows beluga density for each project component. This method was used for estimating exposures for Cook Inlet beluga whales (Table 57). Average densities for Level A and Level B zones may differ for several reasons. For actions happening near the interface of land and water, such as sheet pile driving, small Level A zones will not be accessible to beluga whales, whereas the larger Level B zone for the same activity will be accessible. Larger Level B zones may also include additional cells that were assigned different beluga densities in Goetz et al. (2012).

Table 56. Average beluga whale density during late June within predicted Level A and B ensonified areas

Project Component	Average Density within Level A Contour (animals/square kilometer)	Average Density within Level B Contour (animals/square kilometer)
PLF 48-in pipe piles, impact	0.00004	0.00005
PLF 60-in pipe piles, impact	0.00005	0.00005
Temporary MOF 24-in pipe piles, impact	-	0.00005
Temporary MOF 48-in pipe piles, impact	-	0.00005
Temporary MOF all pipe sizes, vibratory	-	0.00006
Temporary MOF sheet piles, vibratory	-	0.00005
Mainline MOF sheet piles, impact	0.04150	0.04146
Mainline MOF sheet piles, vibratory	0.00000	0.03245
Anchor Handling Location - All	-	0.00551

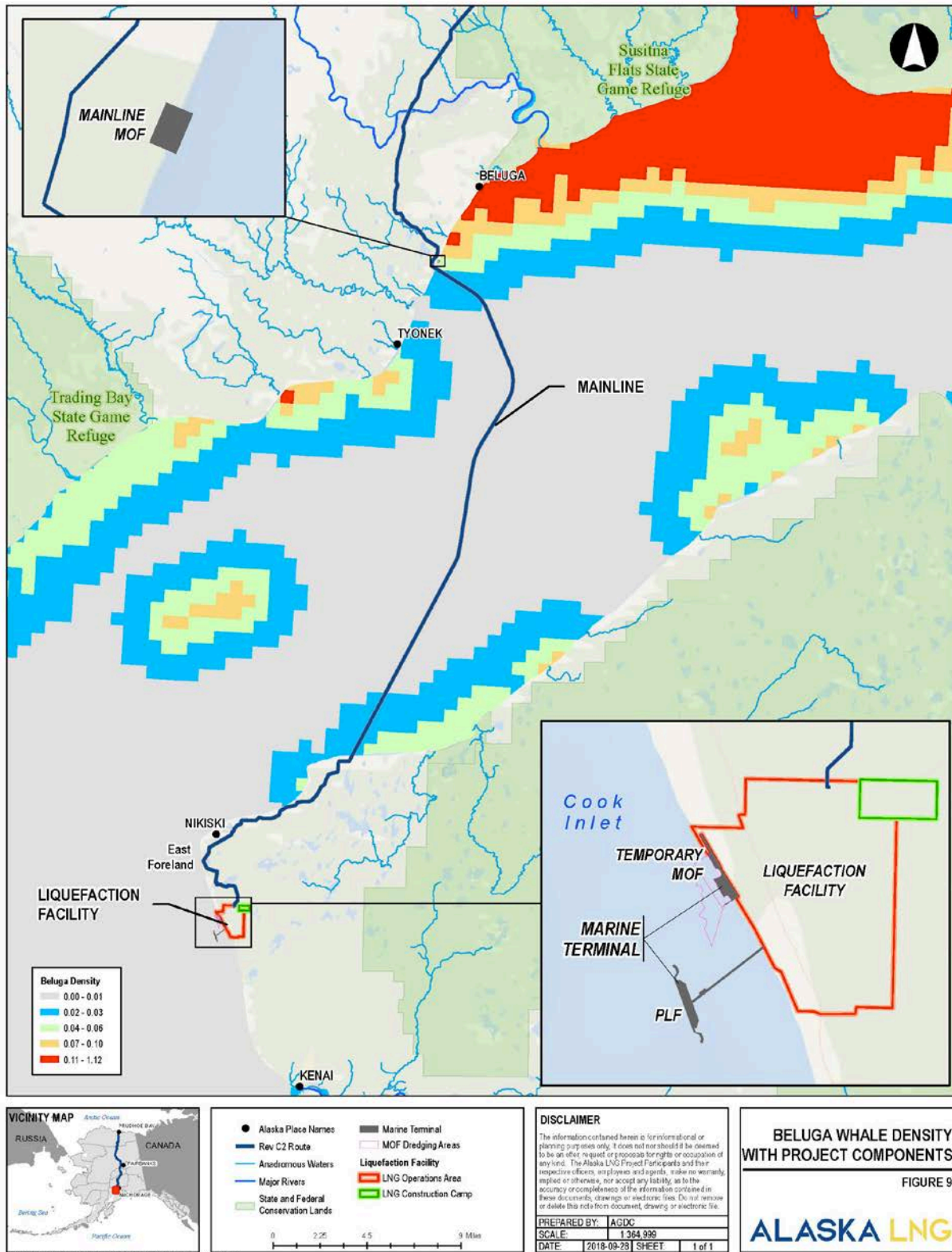


Figure 77. Late June beluga whale density with project components from Goetz et al. (2012).

Finally, NMFS considered group size in determining the exposure estimate for Cook Inlet beluga whales. NMFS recognizes that in certain situations, pile driving may not shutdown prior to whales entering the Level B harassment zone due to: 1) PSOs not seeing the whales, or 2) construction safety concerns. During previous monitoring efforts, sometimes beluga whales were initially observed when they surfaced within the harassment zone. For example, during previous monitoring at the POA (on November 4, 2009), 15 whales were initially observed approximately 950 m north of the project site near the shore, and then they surfaced in the Level B harassment zone during vibratory pile driving (ICRC 2009). Construction activities were immediately shut down, but the 15 whales were documented as takes. In addition, on September 14, 2009, a beluga whale was observed just outside the harassment zone, moving quickly towards the 1,300 meter Level B harassment zone during vibratory pile driving. The animal entered the harassment zone before construction activity could be shut down, and was documented as a take (ICRC 2009).

In addressing the issue of how many belugas may be exposed to pile driving noise at levels capable of causing harassment, we must keep in mind that beluga whales are social creatures that often occur in groups of widely varying sizes. Average density estimates do not adequately account for the rate of whales passing through the opening to Knik Arm, where a measure of passage rate over discrete periods of time, if it were available, would be far superior to a measure of static density in predicting potential rates of exposure at this particular location.

We attempted to account for varying group size and how it may affect the number of animals exposed to pile driving noise. To do so, we considered measures of beluga group size as reported in the long-term scientific monitoring efforts at the Port of Alaska between 2007 and 2011 (POA 2019). This study indicated that of 390 beluga whale groups that were observed, 370 groups (95%) were made up of 11 or fewer animals. Group size exhibited a mode of 1 and a median of 2, indicating that over half of the beluga groups observed over the 5-year span of the monitoring program were individual beluga whales or pairs. About 20 groups consisted of 12 or more whales. To account for the uncommon but foreseeable possibility that large groups of belugas may enter the ensonified area, we augmented the usual density-multiplied-by-area approach by providing an allowance for one large group of 11 beluga whales that plausibly may be exposed during each construction season of work. We did this by simply adding 11 whales per year to our density-based estimates of exposure. We chose a group size of 11 because, as noted above, 95% of observed groups were 11 or fewer, so this should account for the vast majority of expected group sizes occurring in the action area while the project is underway.

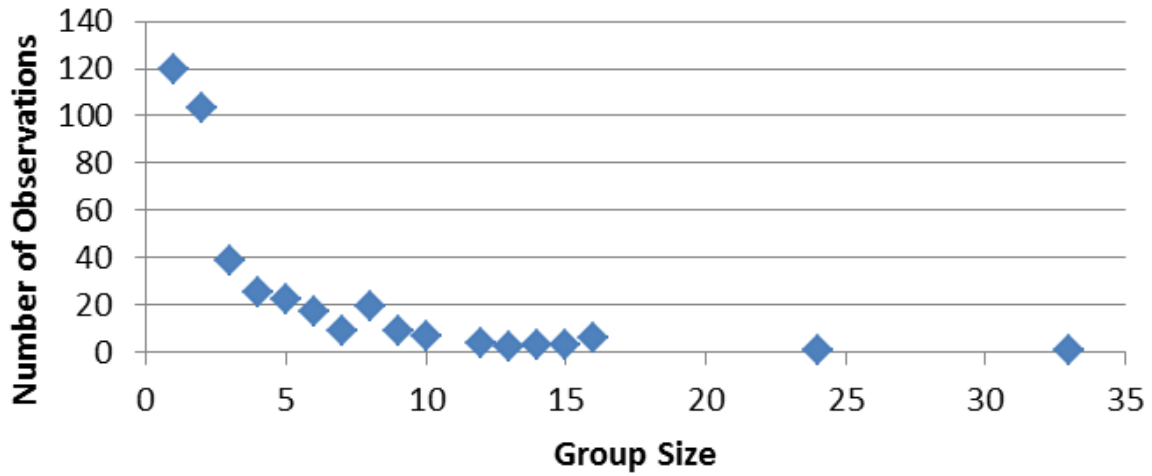


Figure 78. Cook Inlet beluga whale sighting data from Port of Alaska scientific monitoring (Source: APU).

Table 57. Estimated number of marine mammals exposed to noise exceeding Level A and Level B thresholds per season and per facility

Season	Facility	Activities	Humpback whale ^b		Beluga whale (Goetz)	
			Level A	Level B	Level A	Level B ^c
1	Temp MOF	Vibratory & impact sheet & pipe pile driving	0.004	0.995	0.000	0.030
Total Take Season 1^a			0	1	0	11 (0+11 group size)
2	Temp MOF	Vibratory & impact sheet & pipe pile driving	0.046	3.317	0.000	0.101
	<i>Temporary MOF Total^a</i>		<i>0</i>	<i>4</i>	<i>0</i>	<i>1</i>
	Mainline MOF	Vibratory & impact sheet pile driving	0.009	0.082	0.074	1.530
	<i>Mainline MOF Total^a</i>		<i>0</i>	<i>0</i>	<i>0</i>	<i>2</i>
Total Season 2			0	4	0	14 (3+11 group size)
3	PLF	Impact pipe pile driving	0.367	0.312	0.000	0.009
	<i>PLF Total^a</i>		<i>1</i>	<i>1</i>	<i>0</i>	<i>0</i>
	Pipe laying	Anchor handling	0.000	0.219	0.006	0.684
	<i>Pipe laying Total^a</i>		<i>0</i>	<i>1</i>	<i>0</i>	<i>1</i>
Total Season 3			1	2	0	12 (1+11 group size)
4	PLF	Impact pipe pile driving	0.290	0.230	0.000	0.006
	<i>PLF Total^a</i>		<i>1</i>	<i>1</i>	<i>0</i>	<i>0</i>
	Pipe laying	Anchor handling	0.000	0.512	0.006	1.595
	<i>Pipe laying Total^a</i>		<i>0</i>	<i>1</i>	<i>0</i>	<i>2</i>
Total Season 4			1	2	0	13 (2+11 group size)
5	PLF	Impact pipe pile driving	0.773	0.598	0.000	0.016
Total Season 5^a			1	1	0	11 (0+11 group size)
Grand Total for All 5 Seasons			3	10	0	61

Season	Facility	Activities	Humpback whale ^b		Beluga whale (Goetz)	
			Level A	Level B	Level A	Level B ^c
<p>^aRounded up to the nearest whole number, unless the estimated exposure is <0.09, the probability of exposure is extremely small, therefore, the estimate was rounded down.</p> <p>^b Includes Hawaii, Western North Pacific and Mexico DPSs.</p> <p>^cNMFS concludes the amount of take calculated using densities for Cook Inlet beluga whales does not account for the potential of a large group to be exposed to noise above NMFS harassment thresholds, therefore, NMFS added one group of 11 beluga whales to each season of work.</p>						

6.3.1.2 Effects of Pile Driving

There are an ever-increasing number of studies on behavioral responses of cetaceans and pinnipeds to pile driving (Blackwell et al. 2004c; Brandt et al. 2011; Carstensen et al. 2006; Dähne et al. 2013; Kendall and Cornick 2015; Tougaard et al. 2009; Wang et al. 2014; Würsig et al. 2000). Data indicate noise from pile driving can be detected at distances of up to 70 km (Bailey et al. 2010; Southall et al. 2007). General responses of cetaceans from noise associated with pile driving include, but are not limited to, change in vocal behavior and avoidance of the area.

Prudhoe Bay

Bowhead whales

Pile driving at West Dock will occur from June through October, excluding time set aside for subsistence bowhead whale hunting (a period of 4 weeks in the fall). In addition, depending on the time lost to shutdowns for any reason, pile driving may occur in March and April of the second year. The spring migration of bowhead whales into the Canadian Beaufort Sea occurs in mid-May through mid-June, after the springtime pile driving would be complete. In addition, the spring migration occurs over the continental shelf break, well offshore of the action area (Section 4.3.1). Therefore, no exposure of bowhead whales to pile driving noise is expected to occur if March and April are needed to complete construction at West Dock in the second year.

Bowheads may be exposed to noise from pipe and sheet pile driving activities during the summer months and in the fall. Because pile driving is expected to extend into September and October these activities will overlap with the fall migration, which occurs closer to the coastline and nearer to West Dock (Figure 39 and Figure 40). Bowhead whales are not observed migrating inside of the barrier islands (Section 4.3.1, Figure 34 through Figure 42); however, individuals have been observed feeding in gaps between barrier islands (Quakenbush et al. 2013).

Monitoring surveys have been conducted annually since 2001 at the Northstar offshore oil and gas facility located 10 km northwest of West Dock. Over 95 percent of the bowheads observed during fall surveys occurred more than 13.9 miles (22.3 km) offshore in 2001, 14.2 miles (22.9 km) in 2002, 8.4 miles (13.5 km) in 2003, and 10.1 miles (16.3 km) in 2004 (Blackwell et al. 2007). West Dock extends out from the shoreline 2.7 miles (4.3 km) and is within shallow waters

less than 14.2 ft (4.3 m) deep. While a small number of bowhead whales have been seen or heard offshore near Prudhoe Bay in late August (Greene et al. 1999; Blackwell et al. 2007; Goetz et al. 2008, Quakenbush et al. 2013), bowheads are not likely to occur in the immediate vicinity of the proposed activities, in the shallow water of Prudhoe Bay.

Most sounds from the proposed AGDC activities are unlikely to affect bowhead whales because they would not exceed the 120 dB behavioral threshold for continuous noise, and the 160 dB behavioral threshold for impulsive noise, extends 5 km or less, and barrier islands (Reindeer, Midway, Argo) approximately 10-11 km offshore are predicted to provide a “shielding” effect for the propagation of underwater noise (MMS 2002; Richardson et al. 1995; SLR Consulting 2017). Also, described in the prior paragraph, bowhead whales typically travel much farther offshore (Figure 34 through Figure 42).

The response of bowhead whales to impact and vibratory sheet pile driving and impact pipe driving is varied. During the construction of artificial islands and other oil-industry facilities in the Canadian Beaufort Sea in late summers of 1980 through 1984, bowhead whales were at times observed as close as 0.5 mi (0.8 km) from the construction sites (Richardson et al. 1995; Richardson et al. 1990). During these periods, bowheads generally tolerated playbacks of low-frequency construction and dredging noise at received broadband levels up to about 115 dB re 1 μ Pa (Richardson et al. 1990). At received levels higher than about 115 dB, some avoidance reactions were observed. Bowheads reacted in only a limited and localized way (if at all) to construction of Seal Island (10 km northwest of West Dock), the precursor of Northstar, (Hickie and Herrero 1983).

Bowhead whales are not expected to experience PTS from pile driving. The greatest Level A threshold distances are 20 m for vibratory driving of sheet piles and 1,600 m for impact pile driving (48” piles). These zones will be monitored by PSOs and pile driving will be shut down if a bowhead whale enters or appears likely to enter these areas. Because these distances are well within the barrier islands and the water depth out to 1,600 m is 6 m or less, it is highly unlikely that any bowhead whales will be exposed to sound levels that would cause PTS.

Because the Level B harassment zone for bowhead whales is large (4,700 m) there is a greater chance that a bowhead could enter this zone. However, this distance is still well within the barrier islands and the water is only slightly deeper (7.6 m). If a bowhead whale were to enter this zone, noise from pile-driving could disturb the individual and potentially cause TTS. However, we conclude that because bowheads rarely occur inside the barrier islands and because there will be effective implementation of mitigation measures (Section 2.1.2), the probability of harassment due to sheet and cylindrical (pipe) pile driving is very low, but it could cause behavioral effects to the animals exposed. These effects would be temporary in nature and are expected to have a minor effect on the individual.

Ringed and Bearded seals

Ringed and bearded seals could be encountered during construction activities occurring during the ice-covered (March-April) or open-water season. Although acoustic data indicate that some bearded seals remain in the Beaufort Sea year round (Jones et al. 2014; MacIntyre et al. 2013; MacIntyre et al. 2015), satellite tagging data (Boveng and Cameron 2013; Quakenbush et al.

2019) show that large numbers of bearded seals move south in fall/winter with the advancing ice edge to spend the winter in the Bering Sea, confirming previous visual observations (Burns and Frost 1979; Frost et al. 2008; Cameron and Boveng 2009). The southward movement of bearded seals in the fall indicates that very few individuals are expected to occur along the Beaufort Sea continental shelf in February through early April. Ringed seals are more likely to use shorefast ice areas near the West Dock project area during the ice-covered season (Section 4.3.3). If bearded seals are exposed to construction activities during the ice-covered season, responses would likely be similar to those of ringed seals.

Sheet pile driving and pile driving are the loudest noises associated with the proposed action. Effects on ringed and bearded seals are expected to be similar to those observed at the nearby Northstar Island. Behavioral observations at Northstar provided information on seal distribution, abundance, and behavior during periods with and without impact pile driving and other construction activities. Ringed seals were observed in water and on melting sea ice near the island during the installation of sheet pile, slope armor, and conductor pipes during June and July (Blackwell et al. 2004a; Richardson 2008). Ringed seals indicated some degree of tolerance to Northstar sounds as they were frequently observed from vessels and the island, which was likely due to the following factors: apparent low sensitivity to disturbance, habituation, reduced audiometric sensitivity at low frequencies, and potential curious behavior of immature animals (Richardson 2008).

Nearly 55 hours of behavioral observations were documented around the Northstar Island, with 40.25 hours during pipe-driving activities. Of the 23 ringed seals documented, 17 were basking on the ice within 0.5 to 2 km from the eastern edge of the island and 6 were swimming in the moat within 3 to 15 m of the island edge. During pipe-driving activities 15 of these seals were basking on the ice and 5 in the moat. None of the seals reacted to pipe-driving activities, but some reacted to low-flying helicopters (Section 6.4.6). Seals with no observed negative reactions to pipe-driving activities included a juvenile swimming within 3 m of the water's edge (Blackwell et al. 2004a). Blackwell et al. (2004a) noted that the seal seemed unaffected by the acoustic and visual stimuli associated with pipe-driving and approached the water's edge to investigate crews.

Given that seals in the water and on ice did not react to similar construction activities at the Northstar Island and given the implementation of mitigation measures (Section 2.1.2), we conclude that impacts to ringed and bearded seals from the installation of sheet pile and pipe driving will be minor and adverse effects will be limited to behavioral reactions.

Cook Inlet

One temporary and two permanent facilities will be built in Cook Inlet. Vibratory and impact pile driving of sheet and/or pipe piles will occur at all three sites. A Mainline MOF located approximately equidistant between Tyonek and the mouth of Beluga River on the west side of Cook Inlet will be constructed to support installation of the Cook Inlet shoreline crossing, and other onshore construction projects (Figure 8). It would be constructed in year 2. On the east side of Cook Inlet, near Nikiski, a temporary Materials Offloading Facility would be built in years one and two to receive materials needed to construct the liquefaction plant and the permanent PLF. The PLF consists of two berths and a quay. Construction of the PLF would occur in years

three, four, and five. Pile driving would occur from April to October for these projects. Because the construction site near Beluga River has been identified as an area of much greater importance to belugas than the eastside site near Nikiski, we consider the effects to belugas at each site separately.

Cook Inlet Beluga Whales

The combined data for mid-frequency cetaceans exposed to multiple pulses (such as impact pile driving) do not indicate a clear tendency for increasing probability and severity of responses with increasing received levels (Southall et al. 2007). In certain conditions, multiple pulses at relatively low received levels (~80 to 90 dB re 1 μ Pa) temporarily silenced individual vocal behavior for one species (sperm whale). In other cases with slightly different stimuli, received levels in the 120-180 dB range failed to elicit observable reactions from a significant percentage of individuals either in the field or the laboratory (Southall et al. 2007).

As discussed in the *Status of the Species* section (Section 4.3.5), we assume that beluga whale vocalizations are partially representative of their hearing sensitivities. NMFS categorizes Cook Inlet beluga whales in the mid-frequency cetacean functional hearing group, with an applied frequency range between 150 Hz and 160 kHz (NMFS 2016c). For their social interactions, belugas emit communication calls with an average frequency range of about 200 Hz to 7 kHz (Garland et al. 2015). At the other end of their hearing range, belugas use echolocation signals (biosonar) with peak frequencies at 40 to 120 kHz (Au 2000) to navigate and hunt in dark or turbid waters, where vision is limited. Belugas and other odontocetes make sounds across some of the widest frequency bands that have been measured in any animal group. In the first report of hearing ranges of belugas in the wild, results of Castellote et al. (2014) were similar to those reported for captive belugas, with most acute hearing at middle frequencies, about 10 to 75 kHz.

Studies conducted in upper Cook Inlet documented beluga whale responses to pile driving activity (Castellote et al. 2018; Kendall and Cornick 2015). A study conducted during the Port of Anchorage Marine Terminal Redevelopment Project in Knik Arm of Cook Inlet detected that the hourly click rate was higher during times without (429 detected clicks/h) than with (291 detected clicks/h) construction activity; however, the difference was not statistically significant (Kendall et al. 2014). Lower frequency beluga whale vocalizations (e.g., whistles) were potentially masked, there may have been an overall reduction in beluga vocalizations, or it is possible belugas were avoiding the area during construction activity. Kendall and Cornick (2015) visually observed beluga whales before and during pile driving activity at the Port of Anchorage Marine Terminal Redevelopment Project. They observed a decrease in sighting duration, an increase in traveling relative to other observed behaviors, and a change in group composition during pile driving activity. Castellote et al. (2018) indicated masking of beluga vocalizations likely occurs during pile driving activity.

During field observations in the Beaufort Sea, Miller et al. (2005) reported evidence of belugas avoiding large array seismic operations. Further, Romano et al. (2004) found that a captive beluga whale exposed to airgun sounds produced stress hormones with increasing sound pressure levels, and some hormone levels remained high as long as an hour after exposure (but these hormone levels were far less than those produced during beluga whale chase and capture events).

Although the above observations occurred during beluga exposure to sound pressure levels above those that would be produced by the pile-driving proposed for the current project, they demonstrate that belugas are susceptible to sound-induced stress and may be behaviorally and physiologically disturbed by loud noises, potentially leading to restricted use of available habitat when such sounds are produced.

This information leads NMFS to conclude that beluga whales are likely to respond when exposed to sounds produced by pile driving operations. Of the beluga whales that may occur within the Level B harassment zone of pile driving, some whales may change their behavioral state – reduce the amount of time they spend at the ocean’s surface, increase their swimming speed, change their swimming direction to avoid pile driving, change their respiration rates, increase dive times, reduce feeding behavior, and/or alter vocalizations and social interactions (Frid and Dill. 2002, Koski et al. 2009, Funk et al. 2010, Melcon et al. 2012, Kendall et al. 2014, Kendall and Cornick 2015).

Some whales may be less likely to visibly respond if they are foraging. Beluga whales may experience physiological stress responses if they encounter pile driving noise or attempt to avoid pile driving noise and encounter another activity in the project area while they are engaged in avoidance behavior. The implementation of the mitigation measures such as: 1) not starting pile driving if a beluga is observed within the Level B zone; and 2) shutting down of pile driving activities if a beluga is observed within, or likely to enter, the Level B zone will make it very unlikely that a beluga will experience a TTS. However, in the unlikely event that a beluga does enter the Level B zone during pile driving, as described in the *Threshold Shift* Section 6.3.1.1, the severity of TTS depends on the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). If a beluga should experience TTS from noise associated with pile driving activities, a full recovery would be expected within a few days of exposure because of the temporary nature of TTS.

Previous studies and monitoring projects conducted during construction activities at the POA, including pile driving and dredging (Kendall and Cornick 2015), have not shown abandonment of the area during previous periods of heightened sound-producing activities. Belugas continue to travel past the POA during yearly dredging operations (POA 2019b, USACE 2019). During previous POA pile driving activities, as discussed above, some changes in beluga whale behavior have been noted, such as increased travelling behavior and swimming speed, more dispersed groups, and more sightings of lone individuals (Kendall and Cornick 2015), however, belugas continued to travel past the POA to and from upper Knik Arm.

MOF, west side Upper Cook Inlet

The Susitna Delta (including the Little Susitna and Beluga Rivers) is an area that is used extensively by beluga whales, particularly in the summer-fall months. Groups of 200-300 individuals – almost the entire population – including adults, juveniles, and neonates, have been observed in recent years in the Susitna River Delta area (McGuire et al. 2014). Acoustic monitors at the Little Susitna River detected a peak from late May-early June, and a large peak from July-August (Castellote et al. 2016). At the Beluga River (approximately 9 km north of the MOF site), three peaks of occurrence were detected by the acoustic monitors: one from mid-February to early April, the strongest peak in June to mid-July, and a third peak in mid-

November and December (Castellote et al. 2016). NMFS refers to this preferred summer-fall habitat near the Susitna Delta as the Susitna Delta Exclusion Zone and seeks to minimize human activity in this area of extreme importance to Cook Inlet beluga whale survival and recovery. Because construction of the MOF borders this important area, bubble curtains will be tested to see if they make an appreciable reduction in the ensonified area. If found to be effective, they will be employed (Section 2.1.2, mitigation measures 24).

In our analysis we considered the results of a 2016 expert elicitation workshop, in which non-lethal effects of disturbance to belugas were evaluated (Tollit et al. 2016). The non-lethal impacts could include changes in the probability of an individual's survival, production of offspring, or effects on the health of the individual (Tollit et al. 2016). A key assumption of the experts was that "a day of disturbance was defined as any day on which an animal loses the ability to forage for at least one tidal cycle (i.e., it forgoes 50-100 percent of its energy intake on that day)". The median number of days of this kind of disturbance that would result in a detrimental effect to a beluga whale ranged from 16-69 (Tollit et al. 2016).). The number of days that pile driving will occur at the MOF will be 13.4, and no other noise producing activities capable of disturbing belugas will occur on the west side of Cook Inlet in the same season. Thus, there will be approximately two and a half days fewer days of pile driving than the number expected to have an effect on an individual beluga, even in the unlikely scenario an individual beluga lost the ability to forage during every day of pile driving. Given their mobility, the probability that any one individual would be exposed to all 13.4 days of pile driving is unlikely. More importantly, because pile driving operations will shut down whenever a beluga enters, or appears likely to enter, the Level B harassment zone, it is highly unlikely that effects from pile driving would cause any individual belugas to lose the ability to forage for that day.

The implementation of project mitigation measures will decrease the likelihood of exposing belugas to Level B harassment and the likelihood of exposing belugas to noise at levels that would cause disturbance and stress (Section 2.12). These mitigation measures include not pile driving at the Mainline MOF from June 1 to September 7, the use of bubble curtains (if they prove effective), not starting pile driving if belugas are observed in, or appear likely to enter, the Level B harassment zone, and shutting down operations whenever a beluga enters or appears likely to enter the Level B zone. The intention of the mitigation measures is to ensure that there is ample space for belugas to pass by the project area without being exposed to sounds greater than 120 dB and that they have unimpeded access to the preferred habitat in the Susitna Delta. With the implementation of these measures, we conclude that the number of belugas affected at the Mainline MOF will be minimized and the effects to individuals will be minor, but it is possible behavioral reactions could still occur.

PLF and temporary MOF, east side Cook Inlet

While belugas are concentrated primarily in the upper inlet during the summer and fall months, the area around the East Forelands between Nikiski, Kenai, and Kalgin Island appears to provide important habitat for Cook Inlet beluga whales during the winter, early spring, and fall (Castellote et al. 2016, Ovitz 2019). In particular, the Kenai and Kasiloff Rivers are used as foraging habitat in the winter and spring (Castellote et al. 2016, Castellote et al. 2019). The area

where the PLF and the temporary MOF will be constructed is approximately 15 km north of the mouth of the Kenai River. Although the habitat near the construction site is not foraging habitat, because belugas typically travel near the shore, the construction site is in the direct path between beluga winter/spring habitat and their summer habitat to the north. Consequently, there is a high likelihood that belugas would swim near the project area as they make their seasonal migration.

Of the beluga whales that may occur within the Level B harassment zone of pile driving, some are likely to change their behavioral state. For example, behavioral changes could include reducing the amount of time they spend at the ocean's surface, increasing their swimming speed, changing their swimming direction to avoid pile driving, changing their respiration rates, increasing dive times, reducing feeding behavior, and/or altering vocalizations and social interactions (Frid and Dill 2002; Funk et al. 2010; Koski et al. 2009; Melcon et al. 2012). However, because of the mitigation measures in place (shutting down operations whenever a beluga enters, or appears as if it will enter, a Level B harassment zone) we do not anticipate that any of these reactions would result in a beluga losing the opportunity to forage for a tidal cycle. This is especially relevant at this location because it is a travel corridor not a foraging area. Consequently, it is highly unlikely that individual belugas would experience changes in the probability of survival, production of offspring, or effects on the health as identified by the expert panel (Tollit et al. 2016) as a result of this project.

Because of the mitigation measures described in Section 2.1.2 we anticipate that adverse effects to beluga whales will be minimized. Few, if any, exposures should occur at received levels greater than 160 (impulsive pipe driving) or greater than 120 dB (non-impulsive vibratory sheet pile driving). We anticipate that any exposures may cause a temporary behavioral effect without lasting consequences to the fitness of the individual.

Humpback whales

Both pile driving and vibratory sheet pile driving are within the hearing range of humpback whales (7 Hz to 35 kHz), and these whales will likely hear the noise associated with these activities at great distances. As discussed in Section 6.2, baleen whales have shown strong overt reactions to impulsive noises, such as seismic operations, at received levels between 160 and 173 dB re 1 μ Pa rms (Gailey et al. 2007; Ljungblad et al. 1988; McCauley et al. 2000; Miller et al. 2005; Richardson et al. 1986). In addition, baleen whales often detour around drilling activity when received levels are as low as 119 dB re 1 μ Pa rms (Malme et al. 1983, Richardson et al. 1986). Therefore, humpback whales may be even less tolerant of vibratory sheet pile driving activity than the pile driving activity.

Humpback whales have been observed throughout Cook Inlet, however they are much more common in lower and mid Cook Inlet from Kachemak Bay on the east to Kamishak Bay on the west (Section 4.3.4). Thus, nearly all humpback whales that might occur in Cook Inlet will be approximately 100 km south of construction activities occurring at the PLF at Nikiski. However, observations of humpback whales in upper Cook Inlet have increased in recent years. Therefore, we expect that pile driving activities could disturb some individuals.

Given the detour response noted above to drilling activities, humpback whales may avoid ensonified zones altogether. However, shutdown zones will prevent exposure of humpback

whales to sounds that would cause PTS. TTS may occur if a humpback whale enters the Level B harassment zone. If a humpback whale should experience TTS from noise associated with pipe driving or vibratory sheet pile driving activities, a full recovery would be expected within a few days of exposure because of the short-term nature of this condition and short-term exposure. For these reasons we conclude that few (if any) exposures would occur at received levels >160 (impulsive pipe driving) or > 120 dB (non-impulsive vibratory sheet pile driving) due to avoidance of high received levels and shutdown mitigation measures. Therefore, the effects of pile driving on humpback whales is expected to have a minor behavioral effect on a few, if any individuals.

6.3.1.3 Effects of anchor handling/dynamic positioning

For offshore pipelaying of the Mainline across Cook Inlet, conventional pipelay vessel methods would be used. The pipelay vessel typically uses 12 anchors and three anchor handling attendant tugs (AHTs) to maintain a stationary position while the pipeline is installed along the seafloor. Anchor handling tugs may affect listed species through underwater noise, vessel strike, entanglement, and seafloor disturbance. Because the AHT are moving at very slow speeds, the risk of vessel strike is practically non-existent. The effects of seafloor disturbance and habitat alteration from anchors in contact with the seafloor are discussed in Section 6.4.5 and are expected to be minor and temporary. To prevent entanglement in cables used for anchoring, pipe-pulling, and obstacle removal, the cables will be kept under tension at all times, and PSOs will monitor a 2,900-m clearing zone prior to the start of work, since activities cannot start and stop. Beluga whales occurring within this clearing zone during anchor handling operations will be recorded as having been taken by harassment.

Underwater noise is the primary stressor to marine mammals resulting from anchor handling. AHTs are the loudest source of underwater sound for pipelaying activities. Noise generated by these AHTs is considered a stationary and non-impulsive source of underwater sound.

The pipeline crossing of Cook Inlet will occur between April and October in 2023 and 2024 (Seasons 3 and 4). Work from the pipelay vessel and pull barge will be conducted 24 hours per day, 7 days per week, until the work planned for that season is completed. Noise from anchor handling and dynamic positioning is intermittent during pipelaying activities (Table 53). Intermittent vessel noise is produced by AHTs when using thrusters to maintain or adjust vessel position in currents and winds, or when moving the pipelay vessel to a new location.

NMFS estimated underwater sound levels associated with offshore pipelay and trenching operations when engaging thrusters and anchor handling from measurements by Blackwell and Greene (2003). NMFS used a sound source level of 179 dB re 1 μ Pa at 10 m and modeled the distance to the Level B threshold for activities requiring anchor handling/dynamic positioning (Table 53). Although AGDC has agreed to implement a shutdown zone (Table 27) for operational and human safety reasons, and because the area of the shutdown zone is so large, it may not always be possible to shut down immediately when a marine mammal is observed within the Level B zone; therefore, some take of listed species could occur.

Anchor handling during trenching and pipe laying could adversely affect listed marine mammals in the Cook Inlet portion of the action area by exposing them to elevated noise levels. Noise

generated from anchor handling has the potential to startle, increase stress, or disrupt behavior for individual or small groups of marine mammals. Therefore, AGDC has requested authorization for small amounts of Level B take for beluga and humpback whales during pipelaying activities that require anchor handling and dynamic positioning (Table 51).

AGDC has agreed to implement several mitigation measures to minimize: 1) the number of animals exposed to underwater sound above the Level B threshold; and 2) the duration of that exposure to the extent practicable (Section 2.1.2). These measures include the use of PSOs to monitor for marine mammal presence from either the pipelay vessel, land, or both, and implementation of a 2,900 m shutdown zone during anchor handling activities. It is not always safe or possible to halt anchor handling activities immediately when a whale is observed approaching or within the Level B zone. To minimize the duration of Level B exposure, if anchor handling or dynamic positioning are in progress when a humpback or beluga whale enters the shutdown zone, and the crew cannot stop activity immediately, the crew will complete the activities requiring anchor handling or dynamic positioning that are currently underway, and suspend additional activities until the whale is no longer within the zone or has not been observed within the zone for 30 minutes. The proposed mitigation and monitoring measures are expected to minimize the severity of such takes to the extent practicable. As described previously, no Level A injury or mortality is anticipated or authorized for this activity because the sound levels and duration of exposure will not reach the Level A threshold.

6.3.2 Vessel Strike

Section 2.1.1.2 describes the marine transportation requirements and proposed transit routes for construction and operation of the Alaska LNG facilities. In general, the project is expected to increase marine vessel traffic in both Cook Inlet and Prudhoe Bay during construction, and between Cook Inlet and markets in Asia or other locations during operation. Table 21, Table 22, and Table 25 summarize the wide variety of vessels proposed for use. Effects from vessels include disturbance from vessel noise (discussed in Section 6.4.7) and injury or death from a collision (vessel strike).

Ship strikes can cause major wounds or death to marine mammals. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or a vessel's propeller could injure or kill an animal below the water's surface. An examination of all known ship strikes for large (baleen and sperm) whales from all shipping sources indicates vessel speed is a principal factor in whether a vessel strike results in death (Laist et al. 2001; Vanderlaan and Taggart 2007). In assessing records with known vessel speeds, Laist et al. (2001) found that most lethal ship strikes on large whales occurred when a vessel was traveling in excess of 24.1 km/h (14.9 mph; 13 kn).

Bowhead whales are among the slowest moving of whales, which may make them particularly susceptible to ship strikes, although records of strikes on bowhead whales are rare (George et al. 2017; Laist et al. 2001). George et al. (2017) examined records for 904 bowhead whales harvested between 1990 and 2012. Of these, 505 whales were examined for scars from ship strikes including propeller injuries. Only 10 whales harvested between 1990 and 2012 (approximately 2 percent of the total sample) showed clear evidence of scarring from ship propeller injuries. The low number of observations of ship-strike injuries (along with the very

long lifespan of these animals) suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

On the Pacific coast, an estimated 2.7 humpback whales are killed every year by ship strikes (Barlow et al. 1997). Between 1978 and 2011, there were 108 reports of whale-vessel collisions in Alaska waters. Of these, 93 involved humpback whales (Neilson et al. 2012). While humpback whales are among the marine mammal species most prone to ship strikes in Alaska, the majority of these strikes occur in Southeast Alaska (Neilson et al. 2012).

During 2001, one dead humpback whale came into the Port of Anchorage on the bulbous bow of a ship traveling from Seattle. However, it was unclear where the initial strike occurred (NMFS Alaska Regional Office Stranding Database accessed May 2017). No vessel collisions or propeller strikes involving humpback whales have been documented in Cook Inlet.

Ship strikes of smaller cetaceans such as beluga whales are much less common, possibly due to their smaller size and more agile nature. However, while likely rare, vessel strikes of belugas have been documented in the St. Lawrence River Estuary (Lair et al. 2015). In addition, in Cook Inlet, a dead beluga whale washed ashore in 2007 with “wide blunt trauma along the right side of the thorax” (NMFS 2008a), suggesting a ship strike was the cause of the injury. In October 2012, a necropsy of another Cook Inlet beluga carcass indicated the most likely cause of death was “blunt trauma such as would occur with a strike with the hull of the boat” (NMFS AKR, unpub. data). Scarring consistent with propeller injuries has also been documented among Cook Inlet belugas (McGuire et al. 2011).

The agility of pinnipeds and habituation to vessel traffic is likely to preclude collision with vessels. There have been no reported vessel strikes of ringed or bearded seals in the Arctic. Vessel traffic originating from West Dock and the Endicott Causeway has been occurring in the nearshore environment of the action area for many years. As such, pinnipeds may be habituated to the anthropogenic activities. Pre-existing levels of vessel activity have not been shown to adversely affect seals, such as vessel activity associated with the Nikaitchuq offshore drilling site west of Foggy Island Bay in Simpson Lagoon (BOEM 2017b).

NMFS assumes that any project vessel passing through the Aleutian Islands will abide by the International Maritime Organization’s Aleutian Islands Areas to be Avoided (ATBA) guidelines. These guidelines recommend that ships 400 gross tonnages and above on international voyages through the Aleutian Island region use the Northern and Southern Great Circle routes. Vessels in transit to or from the project through the Aleutian Islands would travel in established shipping lanes; sailing on routes well offshore of the Aleutian Islands whenever possible; and avoid travel through the ATBA (FERC 2019).

With strict adherence to the mitigation measures (Section 2.1.2), including maintaining a vigilant watch for marine mammals during all vessel operations, speed restrictions, and timing restrictions, a vessel strike of a listed species from construction vessels is unlikely to occur. However, given the duration and number of vessel transits proposed for the operation phase of the project, small numbers of vessel strikes could occur.

Vessels transiting during the construction phase of the project will be under contract and required

to abide by the mitigation measures in Section 2.1.2 (mitigation measures 37-49). These mitigation measures will reduce the likelihood of take by vessel strike, so NMFS assumes that no vessel strikes will occur during the construction phase. Action agencies and AGDC will not have control over LNG carriers during the operational phase of the project. Therefore, NMFS assumes that in the absence of contractually-required mitigation measures, there is an increased probability of vessel strike during project-related shipping.

To calculate the number of whales that may be struck by project vessels and bulk LNG carriers, we considered past strike data (Neilson et al. 2012; NMFS unpublished data) and existing records of vessel traffic in Alaska from the waters along the Aleutian Islands (Nuka Research and Planning Group 2015a), Cook Inlet (Eley 2012), and south to Dixon Entrance (Nuka Research and Planning Group 2012)(Table 58 and Table 59). In addition, we considered the fact that struck whales are often not detected, and that vessels departing Alaska for trans-oceanic journeys that may unknowingly strike whales are unlikely to retain those whale carcasses on their bow until they make their next port call, or they may not report those whale carcasses back to the United States. We used our best professional judgement in estimating this correction factor because we are unaware of data to support or refute the assumptions we have made. Consequently, in estimating the number of whales that may be struck as a result of this project, we applied a correction factor of 1.5. In this way, if we initially calculated 4 whales to be struck based upon known reports of past struck whales, we applied our correction factor to conclude that 6 whales were likely to have been struck (4 known and reported strikes and 2 undocumented strikes).

Table 58. Estimated number of vessel strikes from 1978 - 2019

Species	Number of Vessel Strikes			
	1978 - 2011 (Neilson et al. 2012)	2012 – 2019 (NMFS Stranding Database)	1978 - 2019 Total	Correction Factor of 1.5 applied
Fin whale	3	4	7	10.5
Gray whale	1	1	2	3
Sperm whale	1	2	3	4.5
Humpback whale	93	29	122	183
Beluga whale	1	0	1	1.5

Table 59 summarizes the vessel traffic data that was used to calculate vessel strike rate for vessels associated with the AK LNG project. In order to estimate vessel traffic in Alaska, NMFS assumed that all vessel traffic would transit through Unimak Pass, Dixon Entrance in Southeast Alaska, and/or Cook Inlet. Any traffic that traveled through the Gulf of Alaska is assumed to have transited through or to one of these locations. This was the best available data NMFS found to estimate vessel traffic (Eley 2012, Nuka 2012, Nuka 2015). Existing data indicated the estimated amount of vessel traffic from 1978 through 2019 was 335,011 vessel transits, while

projected project-related vessel transits equals 21,842 (Table 25).

Table 59. Estimate vessel traffic for the Alaska waters used to calculate vessel strike take for the AK LNG project.

Location	Number of Vessel Transits+	Reference
Unimak Pass	5,501	Nuka 2015
Southeast Alaska	1,710	Nuka 2012
Cook Inlet	960 ^a	Eley 2012
Total in a given year	8,171	
Estimated total from 1978 - 2019	335,011	

^aEley 2012 reported 480 port calls or 480 boats entering Cook Inlet, therefore, we multiplied this by 2 to capture the number of transits

The estimated number of vessel transits from 1978 through 2019 was then combined with available information on vessel strikes during that time period. To calculate vessel strike rate during this time period we used the following formula:

of vessel strikes per species / number of vessel transits = vessel strike rate per species

Table 60 outlines the vessel strike rate calculated for each species. This vessel strike rate for each species was then multiplied by the estimated number of transits during the operational phase of the project to determine take:

vessel strike rate x 21,842 vessel transits during AK LNG operations = # of vessel strikes

For humpback whales and beluga whales, the estimated proportion of the population that is listed under the ESA that would be in the marine transit route area was applied to determine the take of ESA listed population. Estimated take was rounded up unless the estimated exposure was less than 0.09 because the probability of exposure is extremely small, and unlikely to occur.

Table 60. Vessel strike rate and estimated vessel strikes during the operational phase of the AK LNG project

Species	Vessel Strike Rate (whales/vessel transit)	Estimated Vessel Strikes during the AK LNG Operation Phase	Estimated Take Rounded Up ^a
Fin whale	3.13423E-05	0.68	1
Sperm whale	1.34324E-05	0.29	1
Humpback whale	0.000546251	12	-

Species	Vessel Strike Rate (whales/vessel transit)	Estimated Vessel Strikes during the AK LNG Operation Phase	Estimated Take Rounded Up ^a
Western North Pacific DPS (0.5%)	-	<0.09	0
Mexico DPS (10.5%)	-	1.25	2
Beluga whale	4.47746E-06	-	-
Cook Inlet DPS	-	<0.09	0

^aRounded up to the nearest whole number, unless the estimated exposure is <0.09, the probability of exposure is extremely small, therefore, the estimate was rounded down.

6.4 Stressors Not Likely to Adversely Affect ESA-Listed Species

As mentioned in Section 6.3.1.1 fin and sperm whales are not observed in upper Cook Inlet or in the Prudhoe Bay project areas, therefore it is unlikely that fin and sperm whales will be affected by dredging, trenching, screeding/grading, geohazard and geotechnical surveys, seafloor disturbance and habitat alteration, and aircraft noise. These species are only expected to be exposed to project stressors due to vessel transit, authorized and unauthorized discharge, and project trash and debris.

6.4.1 Dredging and Trenching for Pipelaying

As described in Section 2, dredging and trenching are proposed in Cook Inlet for the mainline pipeline crossing of Cook Inlet and at the Marine Terminal Materials Offloading Facility (MOF) in Nikiski. No dredging activities are proposed for the Mainline MOF in Cook Inlet, or for construction in the Prudhoe Bay portion of the action area. Trenching will occur nearshore on both sides of Cook Inlet to facilitate pipeline placement.

Effects to listed marine mammals from dredging/trenching include underwater noise, seafloor disturbance and habitat alteration. The effects of seafloor disturbance/habitat alteration and vessel traffic are discussed in Sections 6.4.5 and 6.4.6.

Because dredging and trenching are similar activities that utilize similar equipment, they are analyzed together here. Dickerson et al. (2001) reported SPLs associated with bucket dredging of up to 158 dB re 1 μ Pa at 1 m in upper Cook Inlet. The loudest sound associated with clamshell dredging occurs when the bucket hits the substrate. More sustained sound of 149 dB re 1 μ Pa at 1 m occurs during bucket winching. (Dickerson et al. 2001). If we consider the periodic sound of the bucket strike as an impulsive sound, we see that the 158 dB sound does not exceed the 160 dB Level B threshold. However, averaging the other bucket dredging sounds that are cyclical and more sustained, Dickerson et al. (2001) obtained a value of 149 dB, sound we treat as non-impulsive, and to which we apply a transmission loss coefficient of 15. This yields a Level B threshold (to the 120 dB isopleth) of 86 m.

AGDC will implement mitigation measures that include a 150-m shutdown zone radius for

dredging and trenching activities, to minimize the risk of exposing marine mammals in Cook Inlet to acoustic stressors associated from these activities. If any trenching for pipelaying from a barge held in place by anchor handling is required, AGDC will implement the larger shutdown zone for anchor handling of 2,900 m. With proper implementation of the shutdown zones for dredging and trenching, we conclude that it is extremely unlikely that marine mammals will be exposed to dredging/trenching sounds capable of harassing them. AGDC did not request authorization for Level A or Level B take for this activity.

6.4.2 Screeding/Grading

Section 2 describes how screeding will be conducted at the Prudhoe Bay project site. For the berthing basin, grading will occur through the ice during winter, and screeding will be performed over 13.7 acres (0.06 km²) in the summer immediately prior to each sealift. Screeding and grading are not proposed for the Cook Inlet portion of this project.

Equipment for the through-ice grading work includes excavators, front end loaders, man-lifts, haul trucks, survey equipment, and other ancillary equipment.

Screeding/grading may affect marine mammals directly by introducing underwater noise into the environment (discussed below), and indirectly through seafloor disturbance and habitat alteration (see Section 6.4.5). The underwater sound levels produced by screeding were modeled using sound source levels from Greene et al. (2008) measured during construction of a gravel island in the Beaufort Sea (Northstar Island). The sound source level generated by screeding was calculated at 125 dB re 1 μ Pa rms at 100 m and from that source level, the distance to the Level B threshold for all marine mammals was estimated at 215 m (Section 6.3.1 *Major Noise Sources*).

AGDC proposes a 215-m shutdown zone during screeding and grading activities to be monitored by the equipment operator. With proper implementation of this shutdown zone, we conclude that it is extremely unlikely that marine mammals will be exposed to screeding and grading sounds capable of harassing them.

6.4.3 Ice Trenching

As described in Section 2, seabed preparations (grading of the seafloor) for the Prudhoe Bay barge bridge will be performed through the ice during winter using excavation equipment and ice excavation methods. Ice trenching is not proposed for the Cook Inlet portion of the action area.

Bowhead whales are not expected to be present within the action area during winter when ice trenching is occurring. Bearded seals are also unlikely to be present in winter as they use habitats further from shore, and only occur in the Central Beaufort Sea at low densities in winter; most animals occur in the Chukchi and Bering seas during winter.

Ringed seals may be encountered on floating and shorefast ice within the action area, but are not expected to be present on bottom-fast ice, which typically occurs in waters at depths less than 3 m (9 ft). The proposed barge bridge occurs in an area where bottom-fast ice is expected to occur.

Ice trenching may create in-air and underwater noise disturbance to marine mammals. Ice

trenching produces in-air sound levels of 64.7 dB re 20 μ Pa at 100 m with a Level B threshold distance of less than 2 m (Greene et al. 2008). Ice trenching produces underwater sound levels of 114 dB re 1 μ Pa at 100 m and a Level B threshold distance of 40 m (Greene et al. 2008). AGDC will implement a 40-m shutdown zone to avoid exposures of marine mammals to in-air or underwater noise capable of causing harassment.

In addition to acoustic harassment, seals may be physically harassed, injured, or killed by the use of equipment associated with ice trenching and removal. Specifically, ice trenching activities could disturb ringed seals in their birth lairs. However, ice trenching is proposed to commence in February, before female ringed seals have established their birth lairs (which typically occurs in March). Additionally, ringed seals typically build their lairs on ice over deeper water than the area proposed for ice trenching, where most or all ice is expected to be bottom-fast and unsuitable as seal habitat.

With proper implementation of the 40-m shutdown zone, we conclude that it is extremely unlikely that listed marine mammals will be exposed to ice trenching sounds capable of harassing them.

6.4.4 Geohazard and Geotechnical Survey

Some proposed project activities, such as screeding at the berthing basin in Prudhoe Bay and pipelaying across Cook Inlet, will require bathymetric surveys using either a single beam echosounder, a multibeam echosounder, or side-scan sonar. The operating frequencies and source levels for the survey equipment proposed to be used by AGDC are summarized in Table 11.

It is extremely unlikely that the acoustic devices with operating frequencies above 200 kHz (i.e., side scan sonar, single-beam echosounder, and multi-beam echosounder) will affect the ESA-listed species considered in this opinion because these frequencies are above the assumed hearing ranges of all marine mammal hearing groups (Table 44) which range from 7 Hz to 160 kHz. Additionally, the high frequency pulsed sounds produced by these devices are emitted in narrow beams that are pointed in a downward direction, attenuate rapidly and are extremely unlikely to reach marine mammals unless they were within a few meters of the source and within the narrow beam of sound (i.e., directly under the vessel).

For the reasons outlined above (i.e., inaudibility and spatially limited exposure area), we conclude that it is extremely unlikely that marine mammals will be exposed to sounds from geotechnical and geohazard surveys capable of harassing them. AGDC did not request authorization for Level A or Level B take for this activity.

6.4.5 Seafloor Disturbance and Habitat Alteration

As discussed in Section 2.1.1.1 and 2.1.1.3 the AK LNG project will cause seafloor disturbance and habitat alteration in both Prudhoe Bay and Cook Inlet. The nature of the disturbance is different for each location, so they will be discussed separately. Information quantifying the areal

extent of project impacts on marine habitat is interspersed throughout Section 2.

6.4.5.1 Prudhoe Bay

Project activities that would result in seafloor disturbance at Prudhoe Bay include screeding, grading, pile driving, and filling. Upgrading and widening the causeway road out to Dock Head 4 would require 26 acres of fill. In addition, 33 acres would be filled for the expansion of Dock Head 4. Approximately 13.7 acres of the seafloor would be evened and flattened at the berthing sites at Dock Head 4. Annually a barge bridge would be installed across a 200 m span in the causeway which will require seafloor grading and preparation. Consequently, 60 acres of the seafloor will be permanently lost and approximately 20 acres will be disturbed annually through screeding and seafloor preparation.

Benthic infauna abundance and diversity are very low in this area, probably due to the shallow water depth (< 5 m), freshwater run-off from adjacent rivers, and ice-related stress (Carey et al. 1984). Freezing and thawing sea ice and river runoff during the summer melting season significantly affect the coastal water mass characteristics and decrease the salinity. River outflow and coastal erosion also transport significant amounts of suspended sediments (Dunton et al. 2006). Sea ice pressure ridges scour and gouge the seafloor and move sediments, creating natural, seasonal disruptions of the seafloor. These factors result in an unstable and unfavorable habitat for benthic organisms in the activity area. Bottom disturbance is a natural and frequent occurrence in this nearshore region resulting in benthic communities with patchy distributions (Carey et al. 1984). The low nearshore densities of benthic prey items suggest that the proposed construction activities would have a negligible effect on benthic productivity and would therefore have a minor effect on the prey available to marine mammals in the area.

The primary effects on water quality from construction of the project in Prudhoe Bay would be the temporary suspension of sediment in the water column during seabed preparation (screeding, grading, filling) and pile driving. Seafloor preparation would cause a temporary, localized increase in turbidity and sedimentation in the waters in the vicinity of the project area. The screeding process redistributes seabed materials to create a flat even seafloor surface without the need for excavation or disposal of materials. Screeding would occur each summer immediately prior to the arrival of the first cargo barge.

Bowhead Whales

Because bowhead whales are rarely observed shoreward of the barrier islands where the project will be located, they are highly unlikely to be affected by either the loss of habitat due to fill or by the screeding. The area impacted by habitat alteration is very small, and thus adverse effects to bowhead whales will be immeasurably small.

Ringed and Bearded Seals

Ringed and bearded seals are regularly documented near the project location. However, the impact of habitat alteration is expected to be minor due to the relatively small area affected and its low productivity, and thus adverse effects to ringed and bearded seals will be immeasurably small.

Water quality would be temporarily affected in the localized area surrounding West Dock by increased turbidity. Turbidity and sedimentation rates are naturally high in this region due to ice scouring and gouging of the seafloor, significant delivery of suspended sediments from river outflow, and coastal erosion. Consequently, the additional suspension of sediment from screeing over a limited amount of time and area is not anticipated to have a measureable impact on water quality, prey important to listed marine mammals, nor to marine mammals themselves.

6.4.5.2 Cook Inlet

The following activities associated with project construction would result in seafloor disturbance: pile driving, dredging/trenching, disposal of dredged material, and facility installation. Approximately 51 acres would be disturbed directly by dredging at the MOF, 51 acres for trenching for the Mainline crossing, and 1,200 acres would be disturbed by the disposal of dredged material. Approximately 50 acres of seafloor would be altered due to the installation of the MOF, Mainline MOF and the PLF (see Section 2.1.1.3) for detailed project description). Additional area would be indirectly affected by the re-deposition of sediments suspended in the water column by the dredging/trenching, dredge disposal, and pile driving. Noise created by these activities is covered in Sections 6.3.1, 6.4.1, 6.4.3, and 6.4.2. All of the proposed activities fall within Area 2 of Cook Inlet beluga critical habitat.

The marine habitats of upper Cook Inlet are influenced by extreme tides and currents, the reworking of sediments by currents and seasonal ice, high suspended sediment loads leading to low light transmission through the water column, low primary production, and extreme salinity gradients (Saupe et al. 2014). These factors create a general trend of decreased species diversity in upper Cook Inlet compared to the middle and lower Inlet (Fukuyama et al. 2012). Subtidal invertebrates that have been documented in upper Cook Inlet include isopods, five species of shrimp, mysids, and nerid polychaetes (Houghton et al. 2005a; Houghton et al. 2005b). Fukuyama et al. (2012) found that Upper Cook Inlet had much lower numbers of benthic invertebrate individuals and taxa, most likely due to the extreme physical conditions. AGDC sampled benthic fauna at five locations near the proposed Marine Terminal near Nikiski, and found that the number of individuals and richness (number of taxa) were low. For example, taxa richness per square meter ranged from 5 to 14 taxa and abundance ranged from 80 to 410 individuals per square meter (AGDC 2020b).

Cook Inlet Beluga

Belugas are known to feed on prey including shrimp and schooling or spawning fish (Seaman et al. 1982). Although fish most likely provide the majority of the beluga nutritional requirements, invertebrates are a regular component of their diet in Cook Inlet (Quakenbush et al. 2015). Shrimp, polychaetes, and amphipods made up the bulk of the invertebrate prey found in beluga stomachs from Cook Inlet (Quakenbush et al. 2015).

The results of invertebrate investigations conducted thus far indicate that the benthic habitat that will be disturbed by the project activities in Cook Inlet are of low productivity and are very unlikely to support the high densities of invertebrate prey that might be valuable to belugas. In addition, invertebrates living in the areas to be disturbed are adapted to surviving the harsh conditions found in Cook Inlet. While some invertebrates will be killed immediately by project activities, based on studies of the effects of dredging on invertebrates in other locations, it is

expected that disturbed areas will be recolonized in a relatively short time (Powilleit et al. 2009; Rhoads et al. 1978). A brief analysis of each type of seafloor disturbance follows.

Facility construction

Facility construction represents two disturbances; the permanent loss of habitat when the seafloor is transformed into a facility and the temporary disturbance that occurs with pile driving to build the facilities. Approximately 50 acres of seafloor habitat will be altered due to facility construction. The proposed facilities will be very close to shore where the tidal fluctuations are most extreme and the substrate is composed primarily of glacial silt and fines. A homogenous substrate does not favor species diversity. For these reasons we would not expect benthic invertebrates to be diverse or abundant in the locations that the facilities will be built. Coupled with the overall small loss of habitat compared to what is available, we conclude that the loss of invertebrate prey that will occur due to facility construction will have an immeasurably small effect on beluga whales.

Pile installation would directly disturb and eliminate seabed substrate and also temporarily increase turbidity from suspended sediments. In addition to seafloor disturbance, localized turbidity would increase because of pile driving. However, Upper Cook Inlet is characterized by naturally turbid water due to run off from glacial streams. Any increases in turbidity would be extremely difficult to detect, temporary, localized, and quickly dispersed by tidal currents. The extreme daily tidal variation will disperse and flush suspended solids from localized construction sites.

In general, turbidity associated with pile installation is localized to about a 25-foot (7.6 m) radius around the pile (Everitt et al. 1980). On the west side of Cook Inlet, Beluga River, a river used by belugas for foraging, is approximately 9 km from the proposed Mainline MOF and Mainline entry into the inlet. On the east side, the Kenai River is approximately 15 km south of the proposed Marine Terminal and 35 km south of where the Mainline will exit Cook Inlet. Because of these distances, the very localized turbidity created by pile driving, and the flushing of tides, no measurable impacts to the Beluga River, the Kenai river, or Cook Inlet beluga whale foraging habitats are anticipated from suspended sediment created by pile driving.

In addition, because of shutdown mitigation measures, belugas are not expected to be close enough to the project activity areas to experience direct effects from turbidity.

Dredging and spoils disposal

The largest impacts of the project to the seafloor will be the altered habitat from dredging and the placement of fill. AGDC proposes to dredge approximately 50 ac and dispose of 1,200 cubic yards of spoils in Cook Inlet in one of two sites 4 or 6 miles west of the MOF at Nikiski. Sediment placement will likely alter the benthic conditions of the disposal site in the short term, however, given the large size of the disposal area, the deep water, and the strong currents, we do not expect sediment placement to substantially alter site characteristics in the long term.

Turbidity will temporarily increase at the dredging site and the disposal site and will decline quickly with distance (Efroymsen and Suter 2001; Reine et al. 2012). Dredge plumes generally decayed to background conditions within approximately 200 m from the dredge in the upper

water column and 600 m in the lower water column in monitoring done for the New York/New Jersey Harbor Deepening Project (USACE 2015). Plume signatures at the bottom rarely extended beyond 800 m (USACE 2015). Based on these studies, elevated suspended sediment concentrations at several hundreds of mg/L above background may be present in the immediate vicinity of the dredge but are anticipated to settle rapidly within 600 m of the dredge location or be quickly diluted by tidal action.

Disposal of fill may impact a small percentage of prey species by crushing, dislodging, or smothering (i.e., clogging of the gills or other feeding structures) with the deposited spoils. However, many invertebrates are able to survive burial by burrowing up through the spoils (Powilleit et al. 2009). Any physical changes to this habitat would not likely reduce the foraging quality of surrounding waters (i.e., the localized availability of fish) for beluga whales in a way that can be meaningfully measured.

The effects of sediment suspension will be localized in space and are expected to persist in the area for no more than a few hours at most as tidal action will disperse them to a point where their concentration in the water column is not detectable from the surrounding waters. Much of the larger diameter re-suspended sediment is expected to quickly settle back into the substrate. As explained for pile driving, dredging and spoils disposal are far enough away from important foraging rivers that no negative impact to the rivers, or prey species that use them, is expected. Furthermore, monitoring and mitigation measures will ensure that project activities cease if a beluga whale approaches the 150 m shutdown zone established for dredging (Section 2.1.2). NMFS therefore concludes that any effects related to habitat alteration will minimally affect prey availability, if at all, and direct effects to beluga whales will be avoided through mitigation.

Area 2 of Critical Habitat is largely based on dispersed fall and winter feeding and transit areas in waters where whales typically occur in smaller densities or deeper waters. It includes both near and offshore areas of the mid and upper Inlet. Dredging is planned for periods that are ice-free, reducing the probability that belugas will be present when the work is done as the dredging and spoils disposal are south of the summer concentrations of belugas. However, some belugas may transit near or through the work area. Because belugas live in highly turbid water it is not expected that the temporary and localized increase in suspended solids will impede their ability to transit or forage. The shutdown mitigation measure will prevent them from any direct injury due to dredging. For these reasons, we conclude that the non-auditory aspects of spatially limited dredging and spoils disposal will have an immeasurably small effect on beluga critical habitat.

Trenching and pipelaying

A trench to accommodate the 42" Mainline will cut across Cook Inlet from the MOF near Tyonek to the Marine Terminal near Nikiski. Nearshore, an amphibious or barge-based excavator will be used and in deeper water a trailing suction hopper dredger will be used. The work will be done over two years in the ice-free season. In addition to trenching, when pipe laying is occurring, the pipelaying vessel will be stabilized by deploying 12 anchors. The anchors will be pulled and redeployed as pipelaying progresses. These activities will directly alter the seafloor and create additional turbidity. The effects of this work are similar to those described in detail for dredging and spoils disposal and our conclusions are the same. Although there will be temporary disturbance to the benthic biota, because invertebrate densities in upper Cook Inlet are

low (and likely of low forage value to belugas), because the invertebrates living in these areas are adapted to harsh conditions, and because the disturbed areas will be recolonized relatively quickly there will be minimal impact to beluga whales directly or indirectly via their prey. Increases in turbidity will be temporary, localized and quickly dispersed in the strong currents. For these reasons we conclude that the non-auditory aspects of trenching and pipelaying activities will have a minimal effect on beluga whales and their critical habitat.

Project activities including seabed preparation, dredging, trenching, dredge disposal, screeding, anchor handling, fill placement, and pipelaying will temporarily disturb the seafloor and/or alter habitat for listed marine species or their prey. Facility construction will result in a prolonged or permanent loss of habitat. Effects are expected to be highly localized, and except for the extremely small areas beneath the footprint of the facilities, effects will also be temporary. In Prudhoe Bay, perturbations are expected to persist from days to a few years (due primarily to lack of strong tidal currents where fall storms are the most likely source of natural energy required to reclaim disturbed habitats). The benthic environment of Cook Inlet is highly dynamic due to extreme tidal fluctuations and high silt input from glacial streams. Therefore, disturbed sediments quickly disperse, and disturbances are expected to be very temporary (days to weeks).

In summary, the seafloor disturbance caused by this project will be very small in geographic extent and almost entirely temporary in nature. The overall impact of seafloor disturbance will be extremely minor, and thus adverse effects to listed marine mammals will be immeasurably small.

6.4.6 Aircraft Noise

Fixed-wing aircraft and helicopters would support AK LNG construction activities. Jets would only be used for transporting equipment and personnel between major airports. Section 2.1.1.5 outlines the types and frequency of aircraft use for the construction phase of the project. Marine mammals could be disturbed by the acoustic noise or physical presence of low-flying aircraft.

Helicopters and fixed-wing aircraft generate noise from their engines, airframe, and propellers. The dominant tones for both types of aircraft generally are greater than 500 Hz (Richardson et al. 1995). Richardson et al. (1995) reported that received sound levels in water from aircraft flying at an altitude of 152 m (approximately 500 ft) were 109 dB re 1 μ Pa for a Bell 212 helicopter, 101 dB re 1 μ Pa for a small fixed-wing aircraft, 107 dB re 1 μ Pa for a twin otter, and 124 dB re 1 μ Pa for a P-3 Orion. Greene and Moore (1995) determined that fixed-wing aircraft typically used in offshore activities were capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 162 dB re 1 μ Pa m at the source. In-air sound pressure levels for helicopters have been measured at 84 dB re 20 μ Pa at 300 m (984 ft) (Boeker and Schulz 2010; SLR Consulting 2017).

Penetration of aircraft noise into the water is greatest directly below the aircraft; at angles greater than 13 degrees from vertical, much of the sound is reflected and generally does not penetrate (Richardson et al. 1995). During calm seas, sound is completely reflected at larger angles and does not enter the water. However, during rough sea conditions, airborne sound may penetrate water at angles greater than 13°. Water depth and bathymetry can also influence the propagation of a noise from a passing aircraft into water. In shallow waters, lateral propagation is greater than in deep water, particularly when the sea floor is reflective. As the aircraft's altitude increases, the

base of the cone gets bigger but the sound pressure levels (SPLs) reaching the water surface decrease because of distance.

Duration of underwater sound from passing aircraft is much shorter in water than air; for example, a helicopter passing at an altitude of 152 m (approximately 500 ft), audible in air for 4 minutes, may be detectable underwater for 38 seconds at 3 m (10 ft) depth, and 11 seconds at 18 m (59 ft) depth (Richardson et al. 1995).

Marine mammals could be disturbed by the acoustic noise or physical presence of low-flying aircraft. Airborne noise and visual cues are more likely to disturb individuals resting at the sea surface or hauled out on ice or land (BOEM 2012). Marine mammals underwater at the time of exposure could also be disturbed by noise propagating beneath the surface of the water or by shadows of an aircraft flying overhead. Observations made from low-altitude aerial surveys report highly variable behavioral responses from marine mammals ranging from no observable reaction to diving or rapid changes in swimming speed/direction (Efroymson and Suter 2001; Smultea et al. 2008). In general, it is difficult to determine if behavioral reactions are due to aircraft noise, to the physical presence and visual cues associated with aircraft, or a combination of those factors (Richardson et al. 1995).

Bowhead Whales

There are studies of the responses of marine animals to air traffic but the few that are available have produced mixed results. The nature of sounds produced by aircraft above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, minor and short-term behavioral responses of cetaceans to aircraft have been documented in several locations, including the Arctic (Patenaude et al. 2002; Richardson et al. 1985). Richardson et al. (1995) reported that there is no evidence that single or occasional aircraft flying above large whales in water cause long-term displacement of these mammals.

Different aircraft maneuvers can have varying behavioral effects on bowhead whales. Fixed-wing aircraft flying at low altitude often cause bowhead whales to make hasty dives (Richardson and Malme 1993). Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Repeated low-altitude overflights at 150 m (500 ft) during aerial photogrammetry studies of feeding bowhead whales sometimes caused abrupt turns and hasty dives.

Individual bowhead whales affected by aircraft traffic are expected to exhibit brief behavioral responses. In the Patenaude et al. (2002) study, when bowhead whales did display discernible reactions to aircraft, reactions included abrupt dives, breaching, and short surfacing periods. Helicopters were more likely to elicit responses than fixed-wing aircraft (Patenaude et al. 2002). Patenaude et al. (2002) found that most reactions by bowhead whales to a Bell 212 helicopter occurred when the helicopter was at altitudes of 150 m or less and lateral distances of 250 m or less. The most common reactions were abrupt dives and shortened surface time and most, if not all, reactions seemed brief. However, the majority of bowhead whales showed no obvious reaction to single passes, even at those distances.

Patenaude et al. (1997) found that few bowhead whales (2.2 percent) during the spring migration

were observed to react to Twin Otter overflights at altitudes of 60 to 460 m (197 to 1,509 ft). Reaction frequency diminished with increasing lateral distance and with increasing altitude. Most observed reactions by bowhead whales occurred when the Twin Otter was at altitudes of 182 m (597 ft) or less and lateral distances of 250 m (820 ft) or less. There was little, if any, reaction by bowhead whales when the aircraft circled at an altitude of 460 m (1,509 ft) and a radius of 1 km (0.6 mi). From this study it can be concluded that the effects from an aircraft are brief, and the bowhead whales should resume their normal activities within minutes. Unmanned aircraft systems are not as noisy as fixed-wing and helicopters, so we assume any effects from the use of these aircraft would be even less than the already minor effects from other aircraft.

Given that bowhead whales are rarely observed in the project area inside the barrier islands and the implementation of mitigation measures (see Section 2.1.2), the probability of aircraft traffic disturbing a bowhead whale is very small, and thus adverse effects to bowhead whales are extremely unlikely to occur. Additionally, given the short duration of exposure to aircrafts and the limited reactions bowhead whales have had to aircraft, if a bowhead whale is exposed to aircraft the impact is very minor, and thus adverse effects to bowhead whales will be immeasurably small.

Ringed and Bearded Seals

Ringed and bearded seals may be disturbed year-round from aircraft flying to and from the Prudhoe Bay AK LNG site; however, the presence of bearded seals during the winter months is expected to be minimal. Most studies have analyzed the effects of aircraft on ringed seals. Bearded seals are expected to elicit similar responses to aircraft as ringed seals unless otherwise noted. Ringed seals have displayed various responses to aircraft (Kelly et al. 1986). Aircraft noise may directly affect seals hauled out on ice during molting or pupping; however, the presence of snow cover above ringed seal lairs will reduce the received levels of airborne sound for seals inside lairs (Cummings et al. 1986; Holliday et al. 1983; Kelly et al. 1986). Richardson et al. (1995) noted pinnipeds hauled out for pupping or molting are the most responsive to aircraft. Other authors noted ringed seal responses to aircraft are variable, depending on the time of year and environmental conditions (Alliston 1981; Burns and Frost 1979; Burns and Harbo 1972; Burns et al. 1982).

Born et al. (1999) indicated that the disturbance of hauled out ringed seals can be substantially reduced if a small helicopter does not approach ringed seals closer than 1,500 m. There are reports of seals habituating to frequent overflights to the point where there was no reaction. Richardson et al. (1995) and Hoover (1988) did not attribute seal pup mortality to low-flying aircraft, noting a temporary avoidance behavior reaction to aircraft as close as 76 m. A greater number of ringed seals responded to helicopter presence than to fixed-wing aircraft presence, and at greater distances (up to 2.3 km [1.4 mi] from the aircraft), suggesting sound stimuli trigger escape responses in ringed seal (Born et al. 1999; Smith and Hammill 1981). Kelly et al. (1986) also reported ringed seals leaving the ice when a helicopter was within 2 km (1.2 mi), flying below 305 m (1,000 ft) altitude. However, escape responses are not elicited consistently (Richardson et al. 1995).

Born et al. (1999) reported that the probability of hauled out ringed seals responding to aircraft overflights with escape responses was greatest at lateral distances of less than 200 m (600 ft) and

overhead distances less than 150 m (~450 ft). Individual bearded seals have been documented exhibiting escape reactions when approached by aircraft (Burns and Harbo 1972; Richardson et al. 1995). Born et al. (1999) also reported ringed seals showed a 21 percent probability of fleeing from fixed wing aircraft at 100 m from the aircraft, 6 percent between 100 and 300 m from the flight track, and 2 percent between 300 and 500 m from the flight track. There was no specific study for Northstar operations that documented seal reactions to aircraft; however, incidental observations documented that most seals near Northstar reacted briefly and mildly when a helicopter arrived on the island. Less than 2 percent of seals reacted by diving to fixed-wing aircraft flying at 91 m (300 ft) during aerial surveys conducted in the late ice-covered season (Richardson 2008). Blackwell et al. (2004a) documented that 92 percent (11 of 12) ringed seals reacted to low-flying helicopter operations; however, these reactions were not strong or long lasting, with only 8 percent (1 of 12) seals returning to the water. The remaining 10 seals increased their vigilance and looked at the helicopter (Blackwell et al. 2004a).

Given the short duration of exposure of aircrafts and the altitude of 1,500 ft helicopters and fixed wing will travel (along with additional mitigation measures; see Section 2.1.2), we conclude that the probability of aircraft traffic disturbing ringed and bearded seals is very small, and thus adverse effects to these species are extremely unlikely to occur. Additionally, since seal reactions have previously been documented as temporary and aircraft exposure would be limited in duration, we conclude that if ringed and bearded seals are exposed to aircraft the impact is expected to be very minor, and thus adverse effects to these species will be immeasurably small.

Beluga Whales

Patenaude et al. (2002) found that beluga whales in the Beaufort Sea reacted more strongly to helicopters than fixed-wing aircraft. Reactions increased significantly to helicopters at lateral distances of less than 250 m (820 ft), and belugas reacted more often when fixed-wing aircraft were at altitudes of less than 182 m (597 ft). Luksenburg and Parsons (2009) noted that these reactions may have been elicited by the mid-frequency sound of the aircraft, visual cues, or both.

During the NMFS aerial surveys, which are flown at 800 m, whale groups are known to occasionally split or merge, but seemingly not in response to survey aircraft. Whales are often seen swimming in the same direction and speed throughout the aerial circling procedure, without any observed change in activity (Rugh et al. 2000). Aircraft pose no apparent threat to the whales, and evidence suggests that they have habituated to the aerial traffic generated by several major airports around upper Cook Inlet (Rugh et al. 2000). However, ground-based biologists note that Cook Inlet belugas often dive and remain submerged for longer than is typical when aircraft fly past at low altitudes or circle them (NMFS unpublished data). Individual responses of belugas may vary, depending on previous experiences, beluga activity at the time of the noise, and noise characteristics.

With the implementation of mitigation measures the impact of project aircraft is very minor, and thus the adverse effects to Cook Inlet belugas will be immeasurably small.

Humpback Whales

Research into the responses of baleen whales to aircraft noise is limited, however there have

been a few studies on bowhead and gray whales which can be used to infer the likely responses of humpback whales. The noise and visual presence of aircraft can result in behavioral changes in bowhead whales such as diving, altering course, vigorous swimming, and breaching (Patenaude et al. 2002), slapping the water with flukes or flippers, and swimming away or turning away from the aircrafts flight direction.

Ljungblad et al. (1987) found that gray whale response was heavily influenced by age, sex, and behavior at the time of the aircraft overflight. Calves were seen to swim under their mothers in response to a fixed-wing aircraft flying at an altitude of 305 m. Migrating gray whales changed their speed and course in response to playback of a Bell 312 helicopter, and when the helicopter was below 250 m, reactions included abrupt turns and dives. However mating gray whales did not respond to repeated circling of a fixed-wing aircraft at 320 m.

Some humpback whales have shown a response to an aircraft at 305 m, while other whales have shown no response to an aircraft at 152 m (Richardson et al. 1995). Whales are less reactive in larger feeding or social groups and more reactive in confined waters or with calves. Reactions by cetaceans are likely influenced by group size and behavioral activity (Patenaude et al. 2002; Richardson et al. 1995; Weilgart 2007).

With the implementation of mitigation measures, we do not expect humpback whales to respond to aircraft. For these reasons, the impact of project aircraft is very minor, and thus the adverse effects to humpback whales will be immeasurably small.

6.4.7 Vessel Noise

Section 2.1.1.2 describes the marine transportation requirements and proposed transit routes for construction and operation of the Alaska LNG facilities. In general, the project is expected to increase marine vessel traffic in both Cook Inlet and Prudhoe Bay during construction, and between Cook Inlet and markets in Asia or other locations during operation. Table 21, Table 22, and Table 25 summarize the wide variety of vessels proposed for use. Effects from vessels include disturbance from vessel noise and injury or death from a collision (vessel strike). (Vessel strikes are discussed in Section 6.3.2.)

Disturbance to listed species from vessel noise could occur during all vessel activities. Behavioral reactions of marine mammals to vessels vary depending on the type and speed of the vessel, the spatial relationship between the animal and the vessel, the species, and the behavior of the animal prior to the disturbance from the vessel. Response also varies between individuals of the same species exposed to the same sound. The potential responses of marine mammals to underwater noise, including threshold shifts, masking, behavioral responses, and non-auditory physical or physiological effects were described in detail at the beginning of Section 6.2 and are not repeated here.

The amount of underwater noise produced by project construction vessels is estimated at between 145–175 dB rms (Richardson et al. 1995; Blackwell and Greene 2003; Ireland and Bisson 2016). Large commercial ships, such as tankers and bulk carriers, may produce noise levels ranging upwards of 190 dB rms (Richardson et al. 1995). Project vessels are likely to generate underwater sound levels exceeding the non-impulsive threshold of 120 dB. Although

some marine mammals could receive sound levels in exceedance of the acoustic threshold of 120 dB from these vessels or be disturbed by the visual presence of barges and tugs, take is unlikely to occur.

While listed marine mammals will likely be exposed to acoustic stressors from project vessels, the nature of the exposure (primarily vessel noise) will be low-frequency, with much of the acoustic energy emitted by project vessels at frequencies below the best hearing ranges of listed marine mammals in the action area. In addition, because vessels will be in transit, the duration of the exposure to ship noise will be temporary. NMFS anticipates that at 10 kn, many project vessels will ensonify a given point in space to levels above 120 dB for less than 9 minutes. The project vessels will emit continuous sound while in transit, which will alert marine mammals before the received sound level exceeds 120 dB. Therefore, a startle response is not expected. Rather, slight deflection and avoidance are expected to be common responses in those instances where there is any response at all. The implementation of mitigation measures, as specified in Section 2.1.2, is expected to further reduce the number of times marine mammals react to transiting vessels. Therefore, NMFS concludes that any disturbance of marine mammals from vessel noise will be temporary and unlikely to rise to the level of take and the effects to listed species from vessel noise will be minor.

Pipeline installation across Cook Inlet will be completed with the use of anchor handling attendant tugs (AHTs) to allow the pipelay vessel to maintain a stationary position. Noise generated by these AHTs is considered a stationary source of underwater sound and could rise to the level of take. AGDC has requested authorization of take for anchor handling activities. Noise produced by this specific form of vessel activity is discussed further in Section 6.3.1.3.

6.4.8 Authorized Discharges

Discharges from project activities are regulated by the Environmental Protection Agency through the National Pollutant Discharge Elimination System (NPDES). Marine mammals could be exposed to discharges through marine vessels carrying project materials between ports and project sites or from project facilities. Discharges associated with some commercial marine vessels are covered under a national NPDES Vessel General Permit (VGP) for Discharges Incidental to the Normal Operation of Vessels. Commercial vessels are covered under the VGP when discharging within the territorial sea extending three nautical miles from shore. When vessels are operating and discharging in Federal waters, the discharges are regulated under MARPOL 73/78; the International Convention for the Prevention of Pollution from Ships. The EPA completes consultation on the issuance of the VGP permit with the Services and receives separate biological opinions. Previously, these opinions have concluded that EPA's issuance of the VGP was not likely to jeopardize listed or proposed species or adversely modify designated or proposed critical habitat. Since ESA consultation was successfully completed on this general permit, impacts associated with marine vessel discharges have already been considered, and any incidental take has been accounted for previously and is reflected in the Environmental Baseline. In addition to acquiring all necessary NPDES permits, AGDC will comply with all local, state, and Federal requirements for waste management and disposal.

6.4.9 Unauthorized Discharges

Accidental spills or releases of petroleum products may occur from a variety of sources during the construction and/or operations phase of the project including vessel leaks, onboard spills, pipeline leaks, and spills at land- and shore-based facilities. The size and composition of the spill influences the number of individuals that will be exposed to spilled material and the duration and severity of that exposure. Contact through the skin, eyes, or through inhalation and ingestion could result in temporary irritation or long-term endocrine or reproductive impacts, depending on the duration of exposure. The greatest threat to cetaceans is likely from the inhalation of the volatile toxic hydrocarbon fractions of fresh oil, which can damage the respiratory system (Hansen 1985; Neff 1990), cause neurological disorders or liver damage (Geraci and St. Aubin 1990), have anaesthetic effects (Neff 1990), and cause death (Geraci and St. Aubin 1990). However, for small spills there is anticipated to be a rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh refined oil, which limits potential exposure of whales to prolonged inhalation of toxic fumes.

Natural gas is predominantly methane, which is in the category of asphyxiant toxicants, and displaces oxygen in water and air. A natural gas leak could result in the formation of a hypoxic (low oxygen) zone in the marine environment in the vicinity of the release site, and in the air at the location where the natural gas is surfacing. The size of the zone of low-oxygen and high-methane concentrations is likely to be highly localized, given the volatility of natural gas. If a significant hypoxic zone is created by a continuous natural gas discharge, marine mammal species or their prey could be affected.

To minimize the potential for an inadvertent release of petroleum products, or other fluids, AGDC will adhere to the fueling, storage, containment, and cleanup measures described in its Project Spill Prevention, Control, and Countermeasure (SPCC) Plan. To minimize the risk of a spill, AGDC will ensure that all contractors comply with the Project SPCC Plan and Stormwater Pollution Prevention Plan. AGDC will develop facility/work site-specific SPCC plans prior to construction, and contractors will be required to develop their own site-specific SPCC plans that would be subject to project review and approval, as discussed in section 4.2.6 of the EIS. Measures outlined in the Project Wetland and Waterbody Construction and Mitigation Procedures and SPCC Plan that would be implemented during construction include secondary containment for single-walled containers; parking and fuel setbacks from sensitive features such as waterbodies and wetlands; and daily maintenance and inspection of construction equipment for leaks. Additionally, the Project Procedures and SPCC Plan include preventive measures such as personnel training, equipment inspection, and refueling procedures to reduce the likelihood of spills, as well as mitigation measures, such as containment and cleanup, to minimize potential impacts should a spill occur. Implementation of the Project SPCC Plan and Procedures would reduce the likelihood of spills and the magnitude of spills should they occur. If a spill should occur, adherence to measures in the Project SPCC Plan would decrease the response time for control and cleanup, thus avoiding or minimizing the effects of a spill on federally listed species.

Oil spill response plans will be provided by AGDC for accidental releases of oil. In addition, LNG carriers are required to develop and implement a Shipboard Oil Pollution Emergency Plan, which includes measures to be taken when an oil pollution incident has occurred or a ship is at risk of one.

Because small spills of harmful pollutants, if they do occur, would be very localized and would disperse, evaporate, and weather rapidly due to wind and tidal currents, NMFS concludes that small spills of harmful pollutants are extremely unlikely to result in exposure of marine mammals to those pollutants. Implementation of state-regulated spill response plans will further reduce the likelihood of such exposure. Large oil spills are unlikely to occur because large quantities of oil are not expected to be transported as part of the AK LNG project construction and operation. However, releases of natural gas are possible during operation of the AK LNG project.

Small releases of natural gas are likely to occur during the operations phase of this project. Large releases are far less likely, but have recently occurred within Cook Inlet, and are therefore expected to occur again. Little is known about the effects of underwater leaks of natural gas (Council of Canadian Academies 2016). Underwater releases of natural gas typically bubble to the surface and dissipate into the atmosphere. However, some natural gas may dissolve into water and displace oxygen near the source of the leak. Large and sustained underwater natural gas releases, such as occurred due to a leaking gas pipeline in Cook Inlet in 2017, could create zones of hypoxia in the water, potentially harming marine mammal prey items. Hypoxic conditions are not expected to directly affect marine mammals, other than by affecting prey availability, and in those instances, such a localized area and small number of prey will be affected as to have no measurable effects upon overall marine mammal prey availability. Therefore, the effects of small or large releases of natural gas on listed marine mammals are expected to be only temporary and minor.

6.4.10 Non-native species

Throughout the world, introduced invasive species have caused havoc in existing ecosystems. The impact of nonnatives in marine systems includes extirpation of native species through competition or predation, a decline in biodiversity, shifts in ecosystem food webs, and changes to the physical structure of the habitat (Norse and Crowder 2005; Trombulak et al. 2004). Ballast water, used by many vessels associated with this project, is an important vector for introducing exotic species. LNG carriers would dock and load at the PLF in Cook Inlet and Heavy Lift Vessels would dock at West Dock in Prudhoe Bay. Ballast water discharged from these carriers would consist of open-ocean water collected during ballast water exchange performed during transoceanic shipping, in accordance with international convention. As LNG is loaded onto the LNG carriers at the PLF, the LNG carriers would release the ballast water, thereby replacing the seawater with LNG product to maintain stability of the LNG carrier.

FERC and AGDC do not have authority or control over independent vessels that would be used for construction and operation of the project. However, the LNG carriers and marine barges to be utilized would be commercial maritime vessels obligated to meet the requirements of the Coast Guard and EPA's General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP) regulations. Coast Guard regulations provide guidance to the maritime industry and Coast Guard personnel relative to the implementation of Ballast Water Management (BWM) system requirements. Coast Guard regulations were enacted to phase out harmful ballast water exchange practices. A Coast Guard-approved BWM system would be required for all LNG carriers and Heavy Lift vessels.

Discharges of a pollutant into the navigable waters of the United States requires authorization under the CWA. In 2013, the EPA issued a NPDES permit, the VGP, which sets numeric effluent limits for ballast water discharges from certain large commercial vessels. The standard is expressed as the maximum concentrations of living organisms in ballast water. The permit also includes maximum discharge limitations for biocides and residues. The VGP has additional requirements for periodic sampling, including calibration of sensors, sampling of biological indicators, and sampling of residual biocides. Under the EPA VGP, there are numerous mandatory ballast water management practices that would be carried out by masters, owners, operators, or persons-in-charge of project vessels equipped with ballast water tanks operating in U.S. waters.

In addition to these federal requirements, vessels calling on Alaska ports must also comply with state ballast water exchange rules and laws. Ballast water discharges are regulated under AS 46.03.750(a)(b), which states: “Except as provided in (b) of this section, a person may not cause or permit the discharge of ballast water from a cargo tank of a tank vessel into the waters of the state. A tank vessel may not take on petroleum or a petroleum product or by-product as cargo unless it arrives in ports in the state without having discharged ballast from cargo tanks into the waters of the state and the master of the vessel certifies that fact on forms provided by the department. (b) The master of a tank vessel may discharge ballast water from a cargo tank of a tank vessel if it is necessary for the safety of the tank vessel and no alternative action is feasible to ensure the safety of the tank vessel.”

AGDC has committed to complying with the conditions set forth in the Coast Guard’s Ballast Water Discharge Standards, which require vessels calling at U.S. ports to be equipped with a BWM system, and the EPA VGP. AGDC has developed a BWM Plan that complies with these standards and has committed to having BWM requirements in place to protect against water quality degradation in Cook Inlet and Prudhoe Bay during project construction and operation. In the project BWM Plan, AGDC stated that there would be no discharge of untreated ballast water by construction vessels or LNG carriers into the waters of Cook Inlet or Prudhoe Bay unless that ballast water has been subject to a mid-ocean water exchange (at least 200 nautical miles offshore, and in 200 m of depth). Additionally, AGDC would require that visiting vessels possess documentation to demonstrate compliance with ballast water regulations prior to allowing any ballast water to be discharged into the project’s berthing areas.

We conclude that AGDC’s compliance with the protective federal and state rules and regulations outlined above will minimize the potential to introduce invasive species to Cook Inlet and Prudhoe Bay to the extent that invasive species are not likely to adversely affect listed species.

6.4.11 Trash and Debris

During construction and operation phases in both Prudhoe Bay and Cook Inlet, the AK LNG project will create trash comprised of paper, plastic, wood, glass, and metal from galley and food service operations in support of the project. A substantial amount of waste will be generated from packing materials alone. In addition, construction, production, and decommissioning activities will also have associated refuse. Trash and debris could be released into the marine environment. While this type of trash and debris discharge is illegal, it can pose significant risks to marine mammals. In particular, plastic strapping poses entanglement risk and small plastic

pieces may be ingested. All plastics break down very slowly into microplastic particles which may have long term contaminant and pollution consequences to the health of food web.

AGDC will comply with Federal regulations regarding trash and debris, so the amount of trash and debris occurring within the action area is expected to be minimal resulting in a minor effect on all ESA-listed species in both Prudhoe Bay and Cook Inlet.

6.4.12 Effects of Noise on Prey

Zooplankton

Zooplankton is a food source for several marine mammal species, including bowhead whales, as well as a food source for fish that are then prey for marine mammals. Bowhead whales primarily feed in the eastern Beaufort Sea during the summer and early autumn but will occasionally feed during their fall migration. Copepods and euphausiids were the most common prey item found in stomach samples taken from harvested bowheads in the Kaktovik area between 1979 and 2000 (Lowry and Sheffield 2002).

Population effects on zooplankton could therefore have indirect effects on marine mammals. The primary generators of sound energy associated with the planned activities include vibratory and impact pile driving, vessel traffic, and screeding. Popper and Hastings (2009) reviewed information on the effects of pile driving and concluded that there are no substantive data on whether the high sound levels from pile driving or any man-made sound would have physiological effects on invertebrates. Any such effects would be limited to the area very near (1–5 m) the sound source and would result in no population effects due to the relatively small area affected at any one time and the reproductive strategy of most zooplankton species (short generation, high fecundity, and very high natural mortality).

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

Benthos

Although Cook Inlet beluga whales consume benthic invertebrates regularly, fish are their primary prey. Bearded seals primarily feed on crabs, shrimp, clams, and other benthic organisms. Little information is available on the effects of sound on benthic invertebrates (Hawkins et al. 2015). Direct mortality is highly unlikely from sound generated by the proposed activities. The few studies that have been conducted on impacts similar to those proposed, show mixed results from no effect to developmental anomalies (Hawkins et al. 2015). No adverse impacts on benthic populations would be expected due in part to their large reproductive capacities. Any mortalities or impacts that might occur because of the planned activities are negligible compared to the naturally occurring high reproductive and mortality rates and would be highly localized. We conclude that the impact of sound from all sources to benthic invertebrates is negligible and

therefore would not have a measurable effect on listed marine mammals.

Fish

Fish are the primary prey for beluga whales in Cook Inlet and for ringed seals in the Beaufort Sea, while humpback whales, bowhead whales, sperm whales, fin whales, and bearded seals may also consume fish species.

Impact pile driving has the potential to affect fish given the high source levels and rapid rise times. Fish with swim bladders are particularly sensitive to underwater impulsive sounds due to swim bladder resonance; as the pressure wave passes through a fish, the swim bladder is rapidly compressed and expanded. The swim bladder may repeatedly expand and contract at the high SPL, creating pressure on the internal organs surrounding the swim bladder. There have been several thorough reviews of the literature on the effects of pile driving on fish (Hastings and Popper 2005; Popper and Hastings 2009). The Fisheries Hydroacoustic Working Group (2008) provided criteria agreed to by the Federal Highway Administration, NOAA Fisheries, USFWS, and various state agencies. Another working group (Popper et al. 2014) provided the guidelines in Table 61.

Table 61. Guidelines for assessing acoustic impacts to fish from pile driving

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

Several studies have examined the effects of pile driving on juvenile salmonids in cages (CalTrans 2010; Hart Crowser Inc. et al. 2009; Ruggerone et al. 2014). The results of these studies showed that behavioral response were subtle and there were no short or long term mortalities. In addition, hematocrit and plasma cortisol levels were not significantly related to exposure to sound generated by pile driving (Caltrans 2010).

In contrast to these results, fish kills have occurred from in-water pile driving activities in Puget Sound, San Francisco Bay, and British Columbia, Canada (WSDOT 2019). Dissection of the dead fish (primarily perch species) indicated injuries to the swim bladder and other organs. Sound level measurements at the Mukilteo Test Pile Project (Laughlin 2007) indicated that the estimated sound levels measured at the time of the fish kills there were 209 dB peak, 202 dB rms, and 183 dB SEL for a single strike. Many of the killed fish were pile perch.

For this project, no peak sounds are expected greater than 213 dB, the level that would injure fish without a swim bladder. However, in both Prudhoe Bay (14” H-piles, 48” pipe piles) and in Cook Inlet (48” and 60” pipe piles) impact driving is expected to range from 207 to 210 dB peak, which could cause injury to fish. The requirement for a soft start to impact pile driving should avoid most, if not all, injuries to fish. The soft start is comprised of an initial set of three strikes from the hammer at about 40 percent energy, followed by a 30-second waiting period, then two subsequent three-strike sets with associated 30-second waiting periods at the reduced energy. The lower energy level will be less than that which causes injury to fish with swim bladders. It is anticipated that any fish that may be near pile driving operations will be scared away during the soft start and would consequently not be injured. In addition, the area in which fish may be affected by pile driving is extremely small compared to the area of habitat available.

Although impact pile driving can cause fish mortalities, it has not been documented for vibratory pile driving (Burgess et al. 2005). Prolonged (more than one hour), close (<10m) exposure could potentially affect the hearing of fish (Burgess et al. 2005), however, it is highly unlikely that this kind of exposure would occur in a natural setting. For these reasons we conclude that vibratory impact driving would not have an effect on prey species.

Fish have been shown to react when engine and propeller sounds exceed a certain level (Olsen et al. 1983; Ona and Godø 1990; Ona and Toresen 1988). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110–130 dB re 1 μ Pa rms (Nakken 1992; Olsen 1979; Ona and Godø 1990; Ona and Toresen 1988). Vessel sound source levels in the audible range for fish are typically 150–170 dB re 1 μ Pa/Hz (Richardson et al. 1995). Based upon the reports in the literature and the predicted sound levels from these vessels, there may be some avoidance by fish in the immediate area or temporary behavioral changes of prey species at close range, such as a startle or stress response. Project-related vessel sounds are not expected to cause direct injury to fish, and will behaviorally affect fish only at close range, for a short period of time.

Based on the above information, fish may respond to noise associated with the proposed action by avoiding the immediate area. However, the expected impact of noise on marine mammal prey will be localized in space and time and immeasurably small, and thus any adverse effects to Cook Inlet beluga whales, bowhead whales, humpback whales, fin whales, sperm whales, and ringed and bearded seals will be negligible.

7 CUMULATIVE EFFECTS

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area (50 CFR § 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

7.1 Prudhoe Bay and Marine Transit Route

We searched for information on non-Federal actions reasonably certain to occur in the Prudhoe

Bay and along the marine transit route portions of the action area in the Bering and Chukchi Seas, through the Aleutian Islands and the Gulf of Alaska. We did not find any information regarding non-Federal actions other than what has already been described in the *Environmental Baseline* (see Section 5 of this opinion). We expect fisheries, subsistence harvest, oil and gas development, scientific research, and commercial shipping activities will continue into the future, particularly in the Bering Sea portion of the marine transit route. Along with these activities, we expect the associated stressors of pollution, underwater noise, entanglement risks, vessel strikes, and competition for prey. We expect increases in fishery-related stressors in the northern Bering Sea, where there have been recent range expansions of commercially harvested species such as Pacific cod and walleye pollock (Thorson et al. 2019). We expect moratoria on commercial whaling and bans on commercial sealing will remain in place, aiding in the recovery of ESA-listed whales and pinnipeds.

Some continuing non-Federal activities are reasonably certain to contribute to climate change within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the *Environmental Baseline* (Section 5.0).

7.2 Cook Inlet

7.2.1 Vessel Traffic and Shipping

Vessel traffic, including shipping, is expected to continue in Cook Inlet.. As a result, there will be continued risk to marine mammals of ship strikes, exposure to vessel noise and presence, and small spills.

7.2.2 Fisheries

Fishing, a major industry in Alaska, is expected to continue in Cook Inlet. As a result, there will be continued risk to marine mammals of prey competition, ship strikes, harassment, and entanglement in fishing gear. For Cook Inlet beluga whales, there is also a notable risk of continued displacement from former summer foraging habitat due to human activity associated with salmon harvest (Ovitz 2019).

NMFS assumes that ADFG will continue to manage fish stocks and monitor and regulate fishing under their jurisdiction in Cook Inlet to maintain sustainable stocks. It remains unknown whether and to what extent marine mammal prey may be less available due to commercial, subsistence, personal use, and sport fishing, especially near the mouths of streams up which salmon and eulachon migrate to spawning areas. In addition, we do not know the full extent of the effects of fishing vessel traffic on availability of prey to belugas. The Cook Inlet Beluga Whale Recovery Team considered reduction in availability of prey due to activities such as fishing to be a moderate threat to the population.

7.2.3 Pollution

As the population in urban areas around Cook Inlet continues to grow, an increase in pollutants entering Cook Inlet is likely to occur. Hazardous materials are released into Cook Inlet from vessels, aircraft, and municipal runoff. Oil spills could occur from vessels traveling within the action area. In addition, oil spilled from outside the action area could migrate into the action area. There are many nonpoint sources of pollution within the action area. Pollutants can pass from streets, construction and industrial areas, and airports into Cook Inlet and beluga whale habitat. The EPA and the ADEC will continue to regulate the amount of pollutants that enter Cook Inlet from point and nonpoint sources through NPDES/APDES permits. As a result, permittees will be required to renew their permits, verify they meet permit standards, and potentially upgrade facilities. However, pollutants of emerging concern such as flame retardants and estrogen mimics are unregulated and are not monitored.

7.2.4 Tourism

There currently are no commercial whale-watching companies in upper Cook Inlet. The popularity of whale watching and the close proximity of beluga whales to Anchorage and the Kenai River during parts of the year make it possible that such operations may exist in the future. However, it is unlikely this industry will reach the levels of intensity seen elsewhere because of upper Cook Inlet climate shallow waters, extreme tides, high turbidity, and swift currents. We are aware, however, that some aircraft have circled around groups of Cook Inlet beluga whales, disrupting their breathing patterns and possibly their feeding activities. NMFS has undertaken outreach efforts to educate local pilots of the potential consequences of such actions, providing guidelines and encouraging pilots to “stay high and fly by.”

Poorly-managed vessel-based whale watching in upper Cook Inlet could cause additional stress to the beluga whale population through increased noise and intrusion into beluga whale habitat not ordinarily accessed by boats. However, within the action area, such effects are unlikely to occur due to the low density of beluga whales and the low likelihood that vessel operators would be able to target them in a commercially viable way.

Avoidance reactions have often been observed in beluga whales when approached by watercraft, particularly small, fast-moving craft that are able to maneuver quickly and unpredictably; larger vessels that do not alter course or speed often cause little to no reaction among whales in Cook Inlet (NMFS 2008a). The small size and low profile of beluga whales, and the poor visibility within the Cook Inlet waters, may increase the temptation for whale watchers and other small watercraft operators to approach the beluga whales more closely than the 100-m minimum approach distance recommended by NMFS marine mammal viewing guidance (<https://alaskafisheries.noaa.gov/pr/mm-viewing-guide>).

8 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step of NMFS’s assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we

add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both the survival or recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in the adverse modification or destruction of critical habitat as measured through direct or indirect alterations that appreciably diminish the value of designated critical habitat as a whole for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 4).

As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival or reproductive success, or lifetime reproductive success of those individuals.

As part of our risk analyses, we identified and addressed all potential stressors; and considered all consequences of exposing listed species to all the stressors associated with the proposed action, individually and cumulatively, given that the individuals in the action area for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range.

8.1 Summary of Stressor-Specific Effects to Species Likely to be Adversely Affected by the Action.

This is a particularly complex proposed action subjecting 12 species and 3 critical habitats located in multiple regions to a wide array of stressors. In the course of crafting this opinion, we drew conclusions regarding project effects on 150 combinations of stressor x species/critical habitat. Below is a concise synopsis of these 150 conclusions, broken down by stressor. This is followed by a more in-depth risk analysis.

1. **Vessel traffic** associated with **construction** of AK LNG facilities is expected to have an extremely low probability of striking any of the species considered in this Opinion and will have no effect upon any of the critical habitats considered.
2. **Vessel traffic** associated with **bulk carriers** transporting LNG is expected to have an extremely low probability of striking the following species throughout the life of this project: blue, sei, western North Pacific gray, bowhead, North Pacific right, or Cook Inlet beluga whales, western DPS Steller sea lions, or ringed or bearded seals. The remaining species considered in this Opinion are likely to be affected by vessel traffic.
3. **Vessel noise** associated with project construction vessels and bulk carriers of LNG is expected to have no more than immeasurably small effects upon all species and critical habitats considered in this Opinion.
4. **Habitat alteration** due to dredging, screeding, pile driving, trenching and disturbances to substrate is expected to have no effect upon blue, sei, sperm, western North Pacific gray, and North Pacific right whales, as well as having no effect upon North Pacific right whale or Steller sea lion critical habitat. It is extremely unlikely to affect fin whales or western DPS Steller sea lions, and any effects upon bowhead and humpback whales, and bearded

and ringed seals are expected to be immeasurably small. This stressor is also expected to have immeasurably small effects on Cook Inlet belugas, while effects to Cook Inlet beluga critical habitat will be immeasurably small or extremely unlikely to occur. .

5. **Pile driving noise** is expected to have no effect upon blue, sei, sperm, western North Pacific gray, or North Pacific right whales, as well as North Pacific right or Steller sea lion critical habitat. It is extremely unlikely to affect fin whales or western DPS Steller sea lions. Effects of pile driving noise on Cook Inlet beluga critical habitat will be immeasurably small. This stressor is likely to adversely affect bowhead, humpback, and Cook Inlet beluga whales, as well as ringed and bearded seals.
6. **Spills and discharges** of contaminants, pollutants and entanglement hazards such as packing straps and discarded lines are expected to have only immeasurably small effects on all species and critical habitats considered in this Opinion.
7. **Aircraft** are expected to have no effect upon blue, sei, sperm, western North Pacific gray, or North Pacific right whales, as well as having no effect upon any critical habitat considered in this opinion. Project aircraft are expected to have only immeasurably small effects upon fin, bowhead, humpback, or Cook Inlet beluga whales, western DPS Steller sea lions, or ringed or bearded seals.
8. Adverse effects due to **invasive species** introduced by project-associated vessels are extremely unlikely for all species and critical habitats considered in this opinion.
9. **Anchor handling**, and the noise associated with it, is expected to have no effect upon blue, sperm, western North Pacific gray, bowhead, North Pacific right whale, or ringed or bearded seals. It is extremely unlikely that anchor handling will affect fin or sei whales or western DPS Steller sea lions, and it will have only immeasurably small effects upon Cook Inlet beluga critical habitat. This stressor is likely to adversely affect humpback and Cook Inlet beluga whales.
10. **Geohazard and geotechnical surveys** are expected to have no effect upon blue, sei, sperm, western North Pacific gray, bowhead, or North Pacific right whales, ringed or bearded seals or any critical habitat considered in this opinion. It is extremely unlikely that these surveys will adversely affect fin, humpback, or Cook Inlet beluga whales, or western DPS Steller sea lions.

We found that blue whales, sei whales, western North Pacific gray whales, North Pacific right whales, western DPS Steller sea lions, North Pacific right whale critical habitat, Steller sea lion critical habitat, and Cook Inlet beluga critical habitat are not likely to be adversely affected by this project due to lack of overlap with stressors, extremely small impact of stressors, the highly improbable chance of stressors occurring, or because of the implementation of mitigation measures that would avoid exposure of animals or critical habitats to the stressor.

8.2 Cetacean Risk Analysis

8.2.1 Bowhead Risk Analysis

Based on the results of the exposure analysis, we expect bowhead whales are likely to be

exposed to underwater noise from sheet pile driving/removal, screeding/under water grading, and trenching activities that may result in take by harassment that is equivalent to MMPA Level B harassment. Impact and vibratory pile driving and removal noise are not likely to result in take of bowheads that is equivalent to MMPA Level A harassment. Exposure to vessel noise, aircraft noise, habitat alteration, vessel strikes, and discharge of pollutants and marine debris (e.g., small oil spills and entanglement hazards) may occur but are considered insignificant (e.g., vessel and aircraft noise) or extremely unlikely (entanglement in debris, struck by a vessel). Our consideration of probable exposures and responses of bowhead whales to proposed construction activities at West Dock is designed to help us assess whether those activities are likely to increase the extinction risks or jeopardize the continued existence of bowhead whales in terms of both survival and recovery of the species.

Mitigation measures required for pile driving/removal and aircraft and vessel operations will further reduce the impacts to bowhead whales. The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have feeding patterns that allow them to acquire energy at high rates. They also have the ability to store substantial amounts of energy, which allows them to survive for months without feeding. The individual and cumulative energy costs of the behavioral responses we have discussed in this opinion are not likely to reduce the overall energy budgets of listed whales. As a result, the whales' probable responses to close approaches by vessels (i.e., reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming direction to avoid vessel or pile driving operations, change their respiration rates, increase dive times, reduce feeding behavior, or alter vocalizations and social interactions) and their probable exposure to noise sources are not likely to reduce the fitness or current or expected future reproductive success of individual bowhead whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

NMFS expects no more than 110 instances of bowhead level B take (harassment) during construction of this project due to instances of exposure to received sound levels ≥ 120 dB re 1 μ Pa rms for continuous noise sources, or ≥ 160 dB re 1 μ Pa rms for impulsive noise sources (Table 51). This estimate represents the total number of takes of bowhead that could potentially occur during construction of this project, not necessarily the number of individuals taken, as a single individual may be taken multiple times over the course of the proposed action. These exposure estimates are likely to be overestimates because they assume a uniform distribution of bowheads and do not account for animals avoiding take before it occurs. Furthermore, we used an open water density estimate to calculate bowhead takes, but bowhead whales are rarely seen inside of the barrier islands, where any acoustic take would occur.

Exposure to vessel noise, aircraft noise, effects of habitat-altering activities, and pollution may occur as part of the proposed action, but are considered minor and are not expected to rise to the level of take. The probability of occurrence of vessel strikes with bowhead whales is extremely unlikely due to: 1) the low density of bowhead whales, 2) the implementation of whale-avoidance mitigation measures, and 3) the small number of vessels associated with the action in areas occupied by bowhead whales. Exposure to harmful marine debris is extremely unlikely due

to mitigation measures and laws governing vessel discharges.

Based on the localized nature of small oil spills, the relatively rapid weathering expected for small spills, the small number of such spills anticipated as a result of the proposed action, and the safeguards in place to avoid and minimize oil spills, we conclude that project-related spills will have an immeasurably small impact on bowheads because any spilled oil is expected to rapidly disperse or become otherwise unavailable to bowheads in concentrations or amounts that may be harmful.

Although construction activities are likely to cause some individual bowheads to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individuals in ways or to a degree that would reduce their survival or fitness. Waters that are acoustically impacted represent a diminishingly small portion of bowhead feeding habitat, and bowheads typically use this area (primarily outside the barrier islands) as a migration corridor, with individual whales spending only a small amount of time within these waters.

The Western Arctic stock of bowhead whales has been increasing at approximately 3.2-3.7 percent per year (Givens et al. 2013; Lowry et al. 2004; Schweder and Sadykova. 2009), while simultaneously exposed to sustained subsistence harvest and oil and gas exploration and development activities in the Beaufort and Chukchi Seas. The maximum theoretical net productivity rate is 4 percent for the Western Arctic stock of bowhead (Muto et al. 2017). The time series of abundance estimates indicates an approximate 50 percent increase in total abundance of bowhead whales during the last ten years, and a doubling in abundance since the early 1990s (LGL Alaska Research Associates Inc. et al. 2014). Despite exposure to oil and gas exploration and development activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2017b), and continued subsistence harvest, this increase in the number of listed whales suggests that the stress regime these whales are exposed to in or near the action area has not prevented them from increasing their numbers in the Beaufort and Chukchi Seas.

Given the life history of bowhead whales and gestational constraints on minimum calving intervals (Reese et al. 2001), and assuming that adult survival rates based on aerial photo-ID data (Schweder et al. 2010; Zeh et al. 2002) and age-at-maturity have remained stable, the trend in abundance implies that the population has been experiencing relatively high annual calf and juvenile survival rates. This is consistent with documented observations of native whalers around St. Lawrence Island, who have reported not only catching more pregnant females but also seeing more young whales than during earlier decades (Noongwook et al. 2007a). While the sample size was small, the pregnancy rate from the 2012 Alaskan harvest data indicated that 2013 calf production was higher than average (George et al. 2011; Lowry et al. 2004; Suydam et al. 2013).

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales will not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the bowhead whale. As a result, the AK LNG project is not likely to appreciably reduce the bowhead whale's likelihood of

surviving or recovering in the wild.

8.2.2 Beluga and Humpback Whales

Based on the results of the *Exposure Analysis*, we expect Cook Inlet beluga whales and Western North Pacific DPS and Mexico DPS humpback whales may be adversely affected by exposure to pile driving and anchor handling noise (Table 57). With the implementation of mitigation measures, exposure to vessel and aircraft noise and presence, screeding and dredging noise, sea floor disturbance, trash and debris, sound from geotechnical and geohazard surveys, and small oil/contaminant spills may occur, but the expected effects to beluga whales and humpback whales are considered immeasurably small and/or extremely unlikely to occur, and are not expected to result in take. Vessel strikes of Cook Inlet belugas by vessels associated with the AK LNG project is extremely unlikely, but vessel strikes of humpback whales by LNG bulk carriers (indirectly associated with the project) are expected. While we do not expect vessels associated with project construction to strike any species (due to the relatively small number of transits and implementation of mitigation measures), we do expect a few vessel strikes of humpbacks by bulk LNG carriers during operations (Table 60). Effects on belugas and humpbacks due to invasive species, and marine debris are extremely unlikely to occur due to implementation of mitigation measures. Finally, the probability of impacts on marine mammal prey occurring from the proposed project is very small, and thus adverse effects are extremely unlikely to occur.

Because it is not possible to identify a humpback whale by DPS in the field without photo-identification linking the animal to its breeding grounds, NMFS AKR uses the estimated percentage of humpback whales in a geographic region by DPS to determine the number of listed animals that are likely to be exposed. Of the humpback whales likely to be adversely affected by this action, we expect 10.5 percent are predicted to be from the Mexico DPS and 0.5 percent are predicted to be from the Western North Pacific DPS (Wade et al. 2016). These proportions are used to estimate exposures of whales within each DPS based on our estimates of exposures of humpbacks overall.

Our estimates of humpback exposure represent the total number of takes that could potentially occur, but not necessarily the number of individuals taken, as a single individual may be taken multiple times over the course of the proposed action.

Based on the localized nature of small oil/contaminant spills, the relatively rapid weathering expected for spilled oil, the small number of refueling activities in the proposed action, and the safeguards in place to avoid and minimize oil spills, we conclude that the effects of an oil spill on Cook Inlet beluga, Mexico DPS humpback, or Western North Pacific DPS humpback whales will be extremely small due to the extreme tidal action in the region, and the resultant dispersal of spilled contaminants. Releases of natural gas during operations (including from bulk carriers) are not expected to have any effect upon these whales due to the extremely volatile nature of LNG and the high likelihood that the liquid will vaporize even before coming into contact with water. LNG that does contact water from above will evaporate without leaving any detectable residue or causing hypoxia in the water column.

As mentioned in the *Environmental Baseline* section, Cook Inlet beluga whales and Western North Pacific DPS and Mexico DPS humpback whales may be impacted by a number of

anthropogenic activities in Cook Inlet. The high degree of human activity, especially within upper Cook Inlet, has produced a number of anthropogenic risk factors that marine mammals must contend with, including: coastal and marine development, oil and gas development, ship strikes, noise pollution, water pollution, prey reduction, fisheries, tourism, direct mortalities, and research, in addition to factors operating on a larger scale such as predation, disease, and climate change. The species may be affected by multiple threats at any given time, compounding the impacts of the individual threats.

We have concluded that the proposed action will have only an extremely small impact on humpback whale populations because upper Cook Inlet, where most effects from Cook Inlet construction will occur, is utilized only occasionally by humpbacks, and then only in very small numbers. Because the action will not reduce the reproduction, numbers, or distribution of the species, NMFS concludes that the proposed action is not expected to appreciably reduce the likelihood of survival or recovery of Mexico DPS or Western North Pacific humpback whales.

Mitigation measures will reduce exposure of listed whales to loud noise from the action by putting into place measures that detect approaching marine mammals and reduce acoustic output if marine mammals appear likely to enter associated Level A and Level B zones. Individual humpback whales may experience Level A and/or Level B acoustic harassment, may experience masking, and may exhibit behavioral responses from project activities. Therefore, we expect some whales may experience stress responses. If whales are not displaced and remain in a stressful environment (i.e., within the harassment zone), we expect the stress response will dissipate shortly after the individual leaves the area or after the cessation of the acoustic stressor. TTS and PTS may occur if a listed species is within the Level B or Level A harassment zone, respectively; however, the severity of TTS and PTS depends on the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). Although pile driving noise is likely to cause individual whales to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, or social dynamics of individual whales in ways or to a degree that would reduce their fitness.

NMFS estimated the Cook Inlet beluga population to be about 279 animals as of 2018, with a 10-year (2008-2018) declining trend of 2.3 percent per year (Shelden and Wade 2019). The revised time-series now shows a clear pattern in the trend in abundance. Following the discontinuation of the subsistence harvest, NMFS expected a 2 to 6 percent recovery annually (NMFS 2008a). The trend reported in Shelden and Wade (2019) indicates the population was initially increasing but then started declining after 2010. The summer range of belugas in Cook Inlet has contracted steadily since the late 1970s (Figure 51). Whereas Cook Inlet beluga whales formerly made more extensive summer use of the waters off of the Kenai and Kasilof Rivers, they now make little to no use of this salmon-rich habitat during summer salmon runs (Figure 54).

Coastal development and boat traffic, especially near Anchorage, has the potential to disrupt beluga whale behavior, and may alter movements among important summer habitat patches through acoustic disruption (e.g., pile driving may hinder passage to or from Knik Arm from the Susitna Delta area). Seismic exploration in upper Cook Inlet has caused both Level A and Level B takes of Cook Inlet beluga whales. Aircraft have been observed to cause behavioral changes in feeding groups of Cook Inlet beluga whales in the Susitna Delta when aircraft circled those

groups. Pollution and contaminants were listed as low relative concern for impeding the recovery of Cook Inlet beluga whales (Muto et al. 2018; NMFS 2016b). Only one known beluga whale mortality associated with fisheries interaction was reported in over 10 years. There is no current subsistence harvest of Cook Inlet beluga whale (Muto et al. 2018).

We considered the possibility that pile driving noise at the mainline MOF could temporarily restrict beluga access to important foraging areas. However, data obtained during recent pile driving activity across several years at the Port of Alaska indicated that belugas have continued to travel past the Port of Alaska to important foraging areas (Kendall and Cornick 2015; POA 2019; USACE 2019) while pile driving was taking place. With the time constraints placed upon pile driving, the distance of the Mainline MOF from the Susitna delta and proposed mitigation measures, we expect that belugas will continue to utilize the important foraging area north of the mainline MOF and will not forego foraging opportunities due to project noise. Pile driving at the Marine Terminal (PLF and temporary MOF) near Nikiski will take place during a time of year when the area is not heavily-relied upon. Belugas use the waters near and offshore from Nikiski primarily in the fall, winter, and early spring. Belugas encountering pile driving near Nikiski are expected to be en route to summer feeding habitat in Northern Cook Inlet, and could easily avoid a close approach to this site without incurring energy costs.

Anthropogenic noise in Cook Inlet remains a concern regarding the recovery of the DPS; however, little is known regarding how possible threats, alone or cumulatively, are impacting recovery of the Cook Inlet beluga whale DPS (NMFS 2016b).

The implementation of the mitigation measures will decrease the likelihood of exposing belugas to noise at received levels that could cause Level B harassment, disturbance, or stress. Additionally, the measures are intended to reduce the likelihood of restricting belugas from utilizing the Susitna delta foraging area. These mitigation measures include not pile driving at the Mainline MOF during peak foraging season in Susitna Delta to the north and shutting down pile driving activities if beluga whales are observed within or likely to enter the Level B harassment zone. For pile-driving at the Mainline MOF near the Beluga River, and on the east side of Cook Inlet near Nikiski associated with the liquefaction facility, AGDC will deploy bubble curtains around piles.¹⁰ If determined feasible the use of a bubble curtain will provide a further reduction the sound source level, currently not accounted for in the estimated Level B thresholds.

As discussed in Section 6, fish may respond to noise associated with the proposed action by avoiding the immediate area. However, the expected impact of noise on marine mammal prey is very minor.

Based on the best information currently available, we do not expect that the proposed action will result in serious injury or mortality of any individual belugas, nor will it be linked to a reduction in the Cook Inlet beluga whale population. Because the action will not reduce the reproduction, numbers, or distribution of the species, NMFS concludes that the proposed action is not expected

¹⁰ If the SSV indicates that the best-performing bubble curtain configuration provides less than a 2dB reduction in in-water sound beyond the bubble curtain, use of the bubble curtain may be discontinued.

to appreciably reduce the likelihood of survival or recovery of Cook Inlet beluga whales.

The stressors discussed in this section are not expected to affect the fitness of individual Cook Inlet beluga whales. Project effects associated with construction are expected to be effectively mitigated through time/area restrictions (e.g., pile driving restrictions at the Mainline MOF), presence of sound reduction devices (e.g., pile driving at the Mainline MOF), efforts of PSOs to avoid exposure (all project locations), or other mitigation measures. While the shipping of LNG by bulk carrier is expected to result in the deaths of a few humpbacks, it is unlikely that the individuals struck will be from the approximately 11 percent that are of the two listed entities. Furthermore, as previously stated, humpback populations continue to grow rapidly. Therefore, the loss of fitness of a few individual whales is not expected to reduce the viability of those whales' populations.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the Cook Inlet beluga, and Mexico DPS or Western North Pacific DPS humpback whale. As a result, the proposed action is not likely to appreciably reduce the Cook Inlet beluga, Mexico DPS or Western North Pacific DPS humpback whales' likelihood of surviving or recovering in the wild.

8.2.3 Fin and Sperm Whales

Fin and sperm whales are likely to experience adverse effects in the form of vessel strikes due to bulk carriers shipping LNG over the life of the project (Table 60). No more than one individual sperm or fin whale is expected to be taken in this way during the 30-year projected lifetime of this project, and no other project-related stressor is expected to have adverse effects on either of these species. Given the extremely small number of potential takes of these species over thirty years (no more than one each) we conclude that this action is not likely to reduce the viability of those populations.

Exposure to vessel and aircraft noise and presence, dredging, screeding and trenching noise, sea floor disturbance and turbidity, trash and debris, discharge of petroleum, and sound from geotechnical and geohazard surveys may occur as part of the proposed action, however, with the implementation of mitigation measures designed to minimize exposure, effects resulting from these stressors are considered highly unlikely to occur or extremely small in impact, and would not rise to the level of take. Exposure to harmful marine debris is unlikely, but exposure to non-biodegradable loops and other entanglement hazards (such as uncut packing straps) remain an unquantifiable threat. With ballast water regulations and an invasive species plan, effects due to presence of invasive species from this project are unlikely.

Based on the localized nature of small oil/contaminant spills (primarily vessel fuel), the relatively rapid weathering expected for spilled oil, the small number of refueling activities in the proposed action, and the safeguards in place to avoid and minimize oil spills, we conclude that the effects resulting in an oil spill that results in fin or sperm whale exposure will be extremely

small due to wind and tidal action, and the resultant dispersal of spilled contaminants. Releases of natural gas during operations (including from bulk carriers) are not expected to have any effect upon these whales due to the extremely volatile nature of LNG and the high likelihood that the liquid will vaporize even before coming into contact with water. LNG that does contact water from above will evaporate without leaving any detectable residue or causing hypoxia in the water column.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the fin and sperm whale. As a result, the proposed action is not likely to appreciably reduce fin and sperm whales' likelihood of surviving or recovering in the wild.

8.3 Pinniped Risk Analysis

Based on the results of the exposure analysis, we expect ringed and bearded seals will likely be exposed to underwater noise from sheet pile driving/removal that will result in takes by harassment that are equivalent to MMPA Level B harassment takes. In addition, impact and vibratory pile driving and removal will likely result in Level A harassment takes of these seals. They may also be exposed to underwater noise from screeding/underwater grading, and trenching activities, but with the implementation of mitigation measures, this take will be extremely unlikely to occur. Exposure to vessel noise, aircraft noise, and habitat alteration may occur but the effects are expected to be immeasurably small. Finally, exposure to vessel strike, small oil spill discharge, and marine debris (e.g., entanglement hazards) is extremely unlikely to occur.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Fall and early winter periods, prior to the occupation of breeding sites, are important in allowing female ringed seals to accumulate enough fat stores to support estrus and lactation (Kelly et al. 2010b). However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of ringed and bearded seals. As a result, the ringed and bearded seals' probable responses (i.e., tolerance, avoidance, short-term masking, and short-term vigilance behavior) are not likely to reduce the fitness or current or expected future reproductive success or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce their survival, abundance, reproduction rates, or growth rates.

NMFS expects no more than 1,765 ringed seals and 300 bearded seals will be exposed to noise from vibratory and impact pile driving and removal that result in Level B behavioral harassment. Pile driving and removal is expected to result in up to 32 instances of Level A exposure to ringed seals and 5 instances of Level A exposure to bearded seals.

These estimates represent the total number of takes that could potentially occur, not necessarily

the number of individual seals taken, as a single individual may be “taken” multiple times over the course of the proposed action.

Exposure to vessel noise, aircraft noise, effects of habitat-altering activities, and pollution may occur as part of the proposed action, but are considered minor and are not expected to rise to the level of take. The probability of occurrence of vessel strikes with ringed or bearded seals is extremely unlikely due primarily to the seals’ agility, but also due to: 1) the low density of seals, 2) the implementation of mitigation measures designed to reduce take, and 3) the small number of project vessels. The lack of any known vessel strikes upon these species strongly indicates the extremely low risk of such a strike occurring as a result of this action. Exposure to harmful marine debris is extremely unlikely due to mitigation measures and laws governing vessel discharges.

Based on the localized nature of small oil spills, the relatively rapid weathering expected for small spills the small number of such spills anticipated as a result of the proposed action, and the safeguards in place to avoid and minimize oil spills, we conclude that the probability of a project-related small spill exposing ringed or bearded seals to contaminants is highly unlikely. If exposure were to occur, the effects would be minor because the oil is expected to rapidly disperse or become otherwise unavailable to seals. Although the construction activities are likely to cause some individual ringed and bearded seals to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual seals in ways or to a degree that would reduce their survival or fitness because even if the seals are actively foraging in waters around the construction they can avoid intense exposure by lifting their heads above water, or hauling out.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals will not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the ringed and bearded seal. As a result, the AK LNG project is not likely to appreciably reduce the ringed seals’ or bearded seals’ likelihood of surviving or recovering in the wild.

9 CONCLUSION

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS’ biological opinion that the proposed action is not likely to jeopardize the continued existence of bowhead whales, Arctic ringed seals, Beringia DPS bearded seals, Cook Inlet beluga whales, fin whales, sperm whales, Western North Pacific DPS humpback whales, or Mexico DPS humpback whales. NMFS also concludes that the proposed action is not likely to adversely affect blue whale, North Pacific right whale, Western North Pacific DPS gray whale, sei whale, Western DPS Steller sea lion, Chinook Salmon ESUs (Lower Columbia River, Upper Columbia River spring-run, Puget

Sound, Snake River fall-run, Snake River spring/summer-run, and Upper Willamette River), and steelhead trout DPSs (Lower Columbia River, Middle Columbia River, Upper Columbia River, Puget Sound, Snake River Basin, and Upper Willamette River) or designated North Pacific right whale critical habitat, Steller sea lion critical habitat, or Cook Inlet beluga whale critical habitat.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species unless there is a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. § 1532(19)). “Incidental take” is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 CFR § 402.02). For this consultation, NMFS Permits Division and FERC anticipate that any take incidental to construction will be by Level A and Level B acoustic harassment.

Section 9 take prohibitions do not apply to threatened species. This Incidental Take Statement (ITS), however, includes limits on taking of threatened species since those numbers were analyzed in the jeopardy analysis and to provide guidance to the action agency on its requirement to re-initiate consultation if the take limit for any species covered by this opinion is exceeded. The ESA does not prohibit the take of threatened species unless special regulations have been promulgated, pursuant to ESA Section 4(d), to promote the conservation of the species. ESA Section 4(d) rules have not been promulgated for Arctic ringed seals or Beringia DPS bearded seals; therefore, ESA section 9 take prohibitions do not apply to these two species. This ITS includes numeric limits on the take of these species because specific amounts of take were analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agency on its requirement to re-initiate consultation if the amount of take estimated in the jeopardy analysis of this biological opinion is exceeded. This ITS includes reasonable and prudent measures and terms and conditions designed to minimize and monitor take of these threatened species.

Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of an ITS.

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the MMPA. Accordingly, **the terms of this incidental take statement and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here (Section 9 of the ESA, however, does not apply to ringed or bearded seals)**. Absent such authorization, this incidental take statement is inoperative.

The terms and conditions described below are nondiscretionary. NMFS Permits Division and FERC have a continuing duty to regulate the activities covered by this ITS. In order to monitor the impact of incidental take, NMFS Permits Division and FERC must monitor and report on the progress of the action and its impact on the species as specified in the ITS (50 CFR

§ 402.14(i)(3)). If NMFS Permits Division and FERC (1) fail to require the permit holder to adhere to the terms and conditions of the ITS through enforceable terms that are added to the authorization, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse.

This ITS is valid only for the activities described in this biological opinion, and which have been authorized under section 101(a)(5) of the MMPA. The taking of ESA-listed species in a manner, or in amounts not authorized under the ITS and MMPA permits may result in the modification, suspension, or revocation of the ITS.

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or utilize a surrogate (e.g., other species, habitat, or ecological conditions) if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (50 CFR § 402.14(i)(1); see also 80 FR 26832; May 11, 2015).

NMFS is reasonably certain the proposed AK LNG project activities are likely to result in the incidental take of ESA-listed species by Level A (ringed and bearded seals in Prudhoe Bay and humpback whales in Cook Inlet) and Level B harassment (bowhead whale, ringed and bearded seals in Prudhoe Bay, and beluga and humpback whales in Cook Inlet) associated with noise from pile driving and anchor handling. NMFS is also reasonably certain the operational activities of the AK LNG project are likely to result in incidental take of ESA-listed species by vessel strike. However, neither NMFS nor FERC have jurisdiction or control over vessels that will transport LNG during the operational phase of the project and cannot impose enforceable monitoring or reporting requirements on such vessels. We analyzed vessel strikes in Section 6 of this opinion and this informed our conclusions in Section 9, but vessel strikes associated with the operational phase of the project are not authorized by this ITS. As discussed in Section 6 of this opinion, the proposed action is expected to result in take of listed marine mammals as indicated in Table 62. For a breakdown of calculations and exposure by stressor see Section 6. The method used for estimating the number instances of take for each species resulting from exposure to sound levels expected to result in Level A and Level B harassment is described in Section 6.

NMFS Permits Division has indicated they will authorize the following number of instances of MMPA Level B take over the 5 year period covered by their incidental take regulations for projects in Cook Inlet: 61 Cook Inlet beluga whales and 10 humpback whales (including Western North Pacific DPS and Mexico DPS). NMFS Permits Division has indicated they will authorize Level B harassment take of 110 bowhead whales, 1,765 ringed seals, and 300 bearded seals in Prudhoe Bay over a 1 year period. Of the humpback whales, 10.5 percent or 1 animal is predicted from the Mexico DPS and 0.5 percent or 1 animal from the Western North Pacific DPS (Wade et al. 2016). Therefore, NMFS AKR is authorizing 1 Level B harassment take for the Mexico DPS and 1 Level B harassment take for Western North Pacific DPS under the ESA.

In addition, up to 3 humpback whales (including Western North Pacific DPS and Mexico DPS) are expected to experience Level A take in Cook Inlet over the 5 year period and 32 ringed seals and 5 bearded seals are expected to experience Level A take in the Beaufort Sea's Prudhoe Bay over a 1 year period. Of the humpback whales, 1 animal is predicted to be from the Mexico DPS

and 0.5 percent or 0 animal from the Western North Pacific DPS (Wade et al. 2016). Therefore, NMFS AKR is authorizing 1 Level A harassment take for the Mexico DPS and 0 Level A harassment take for Western North Pacific DPS under the ESA. Because it is not possible to identify a humpback whale by DPS in the field, NMFS AKR uses the estimated percentage of humpback whales by DPS to determine the number of listed animals that have been taken. As a result, NMFS AKR will not consider that AGDC has reached its ESA take limit until 10 humpback whales have been observed in a Level B zone and 3 humpback whales have been observed in a Level A zone.

Based on the above information, NMFS AKR is authorizing takes for the number of ESA-listed individuals during the construction phase of the AK LNG project described in Table 62.

For humpback whales, given the relatively small likelihood that an individual whale affected by the project is from one of the ESA-listed DPSs, and that it is not possible to distinguish between DPSs in the field, we will consider ESA-authorized incidental take to be exceeded when the AK LNG project exceeds its MMPA-authorized limit on Level A or Level B take of any humpback whales.

Table 62. Summary of expected take associated with the construction activities (pile driving and anchor handling) resulting in incidental take of ESA-listed species by Level A and Level B harassment.

Species	Level A Takes	Level B Takes
Bowhead whale (<i>Balaena mysticetus</i>)	0	110
Ringed seal, Arctic Subspecies (<i>Phoca hispida hispida</i>)	32	1,765
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	5	300
Humpback whale, Mexico DPS ^a (<i>Megaptera novaeangliae</i>)	1	1
Humpback whale, Western North Pacific DPS ^a (<i>Megaptera novaeangliae</i>)	0	1
Cook Inlet beluga whale (<i>Delphinapterus leucas</i>)	0	61
Fin whale (<i>Balaenoptera physalus</i>)	0	0
Sperm whale (<i>Physeter macrocephalus</i>)	0	0

^a NMFS anticipates that 10 Level B takes and 3 Level A takes of humpback whales may occur. Of the total take it is expected that 10.5 percent is from the Mexico DPS and 0.5 percent is from the Western North Pacific DPS (Wade et al. 2016).

10.2 Effect of the Take

In Section 9 of this opinion, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Although the biological significance of the expected behavioral responses of Cook Inlet beluga whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, bowhead whales, ringed seals, and bearded seals remains unknown, this consultation has assumed that exposure to disturbances associated with the AK LNG project activities might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, any behavioral responses of these whales and pinnipeds to major noise sources, and any associated disruptions, are not expected to measurably affect the reproduction, survival, or recovery of these species.

The taking of Cook Inlet beluga whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, bowhead whales, ringed seals, and bearded seals will be by incidental (acoustic) harassment during construction.

10.3 Reasonable and Prudent Measures

Reasonable and prudent measures (RPMs) are those actions “necessary or appropriate to minimize the impacts, i.e., amount or extent, of incidental take” (50 CFR § 402.02). RPMs are nondiscretionary.

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary or appropriate to minimize or monitor the incidental take of fin whales, sperm whales, Cook Inlet beluga whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, bowhead whales, ringed seals, and bearded seals resulting from the proposed action. We are not specifying RPMs to minimize or monitor the incidental take of Mexico DPS humpback whales, sperm whales, or fin whales during tanker operations because the action agencies lack jurisdiction to take or require such measures.

1. The NMFS Permits Division and FERC must require that project personnel monitor all project activities for the taking of marine mammals as described in this Biological Opinion, and that all authorized and unauthorized take of marine mammals be reported to NMFS AKR.
2. The NMFS Permits Division and FERC must implement the mitigation measures described in Section 2.1.2 of this Biological Opinion. In addition, they must monitor, evaluate, and report on the effectiveness of mitigation measures described in Section 2.1.2.

10.4 Terms and Conditions

“Terms and conditions” implement the reasonable and prudent measures (50 CFR § 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

In order to be exempt from the prohibitions of section 9 of the ESA, the NMFS Permits Division, FERC, or any applicant must comply with the following terms and conditions, which implement the RPMs described above. The NMFS Permits Division, FERC, or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR § 402.14).

Partial compliance with these terms and conditions may result in more take than anticipated, and may invalidate this take exemption. These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

To carry out RPM #1, NMFS Permits Division and FERC must undertake the following:

- A. NMFS Permit Division and FERC must fully implement all mitigation measures specified in Section 2.1.2 to ensure minimization and adequate monitoring of take in both Prudhoe Bay and Cook Inlet.
- B. Because MMPA Level A Take of belugas is not authorized, NMFS Permit Division and FERC must ensure that waters within the level A Zone specific to mid-ranged cetaceans (see Table 53, column under headings Level A, Mid-frequency Cetaceans, Modeled Distance) is fully monitored for each activity while it is occurring, and that the activity is shut down whenever one or more belugas cross into that zone or appear likely to do so, or whenever that entire zone cannot be effectively monitored due to environmental conditions.
- C. During Cook Inlet-based pipelaying and trenching activities, PSOs will be on-watch for the duration of the pipelaying/trenching activities, and must be able to effectively monitor for marine mammal presence in the shutdown and monitoring zones for those activities at all times.
- D. The taking of any marine mammal in a manner other than that described in this biological opinion and authorized by this ITS must be reported within 24 hours to NMFS AKR, Protected Resources Division (Table 64).

Table 63. Summary of agency contact information

Reason for Contact	Contact Information
ESA Consultation Questions, Reports & Data Submittal Contact NMFS Alaska Regional Office	Greg Balogh: greg.balogh@noaa.gov , 907-271-3023

Reason for Contact	Contact Information
MMPA Questions Contact NMFS Office of Protected Resources	Jolie Harrison (Jolie.Harrison@noaa.gov) Shane Guan: Cook Inlet issues – shane.guan@noaa.gov Leah Davis: Prudhoe Bay issues – leah.davis@noaa.gov
Stranded, Injured, or Dead Marine Mammal (<i>not related to project activities</i>)	Stranding Hotline (24/7 coverage) 877-925-7773
Note: In the event that this contact information becomes obsolete please call NMFS Anchorage Main Office 907-271-5006	

- E. In the event that the proposed action causes unauthorized take of a marine mammal that results in a serious injury¹¹ or mortality, AGDC shall immediately cease operations¹² associated with the activity that resulted in the serious injury or mortality, and immediately report the incident to NMFS AKR, Protected Resources Division, to the Marine Mammal Stranding Hotline, and to NMFS Permitting Division (Table 29). The report must include the following information:
- i. Time, date, and location (latitude/longitude) of the incident;
 - ii. details on the nature and cause of the take (e.g., vehicles, vessels, and equipment in use at the time of take);
 - iii. an account of all known sound sources above 120 dB that occurred in the 24 hours preceding the incident;
 - iv. water depth at the location of the take;
 - v. environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
 - vi. description of marine mammal observations in the 24 hours preceding the incident;
 - vii. species identification or description of the animal(s) involved;
 - viii. the fate of the animal(s);
 - ix. and any photographs or video footage of the animal obtained.

Activities that may have caused the take must cease upon the occurrence of unauthorized take, and must not resume until NMFS AKR is able to review the circumstances of the prohibited take. NMFS Permits Division and FERC must work with NMFS AKR and the permittee to determine what is necessary to minimize the likelihood of additional prohibited take and ensure ESA compliance. The suspended

¹¹ Serious injury means “any injury that will likely result in mortality” (50 CFR 216.3).

¹² Curtailing of activities should consider human, property, and environmental safety.

- activity must not be resumed, except in protection of human safety as above, until notified by NMFS via letter, email, or telephone.
- F. In the event that an oiled ESA-listed marine mammal is spotted, the permittee must report the incident within 24 hours to NMFS AKR, Protected Resources Division, the Marine Mammal Stranding Hotline, and to NMFS Permitting Division (Table 64).
 - G. In the event that an operator reaches, or appears likely to exceed, the take limits authorized for any specific activity as described in this ITS, the permittee must contact the Alaska Region, Protected Resources Division, and NMFS Permits Division (Table 64). NMFS AKR will work with NMFS Permit Division and FERC and the permittee to determine what is necessary to minimize the likelihood of further take, and determine if reinitiation of consultation is required (50 CFR 402.16).
 - H. Take of phocids in the Beaufort Sea that are within the level A zones indicated in Table 47 will be monitored by monitoring all of the indicated Level A zone, or by monitoring at least 10 percent of that zone (a 36 degree section of the zone) from the sound source out to the indicated Level A threshold, using a sampling and reporting plan that is approved by NMFS AKR, where the effective detection range of phocids is assumed to be no greater than 500 m.

To carry out RPM #2, NMFS Permits Division and FERC must undertake the following:

- A. The permittee must implement all of the mitigation measures presented in section 2.1.2 of this opinion.
- B. The permittee must submit to NMFS AKR annual reports summarizing ESA-listed marine mammal sightings and takes of listed marine mammals. The annual report must contain all of the information indicated in the mitigation measure section of this Opinion (section 2.1.2, measure 64), and must be submitted within 90 days of the cessation of in-water work each year. The draft annual report will be subject to review and comment by NMFS AKR. Comments and recommendations made by NMFS AKR must be addressed in the annual report prior to NMFS acceptance of the annual report. The draft report will be considered final for the activities described in this opinion if NMFS AKR has not provided comments and recommendations within 30 days of receipt of the draft report. In addition to the information outlined in mitigation measure 64 (section 2.1.2), the annual report must contain the following information:
 - i. A description of the implementation and qualitative assessment of the effectiveness of mitigation measures for minimizing adverse effects of the action on ESA-listed species;
 - ii. Lessons learned and recommendations for improvement of mitigation measures and monitoring techniques; and
 - iii. A digital file that can be queried containing all observer monitoring data and associated metadata.

11 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR § 402.02).

The action agencies should work with AGDC to accomplish the following conservation recommendations:

1. Collaborate with Alaska Department of Fish and Game or other partners to estimate the number of each species of anadromous fish returning to spawn in the Beluga River.

In order to keep NMFS's Protected Resources Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS Permits Division and FERC should notify NMFS of any conservation recommendations they implement in their final action.

12 REINITIATION OF CONSULTATION

As provided in 50 CFR § 402.16, reinitiation of consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount of incidental take is exceeded, section 7 consultation must be reinitiated immediately (50 CFR § 402.14(i)(4)).

13 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act (DQA)) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

13.1 Utility

This document records the results of an interagency consultation. The information presented in this document is useful to NMFS Permit Division, FERC, and the general public. These

consultations help to fulfill multiple legal obligations of the named agencies. The information is also useful and of interest to the general public as it describes the manner in which public trust resources are being managed and conserved. The information presented in these documents and used in the underlying consultations represents the best available scientific and commercial information and has been improved through interaction with the consulting agency.

This consultation will be posted on the NMFS Alaska Region website <http://alaskafisheries.noaa.gov/pr/biological-opinions/>. The format and name adhere to conventional standards for style.

13.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

13.3 Objectivity

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 et seq.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the literature cited section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA implementation, and reviewed in accordance with Alaska Region ESA quality control and assurance processes.

14 REFERENCES

- ABR. 2017. Protected-Species Monitoring Report. 2017 Ship Creek Boat Launch Repairs Project, Anchorage, Alaska. Final Report Prepared for R & M Consultants, Inc. 17+pp.
- Adams, J. D., and G. K. Silber. 2017. 2015 Vessel Activity in the Arctic. Pages 171 p. *in* U. S. Department of Commerce, NOAA Technical Memorandum.
- ADEC. 2010. Total maximum daily loads (TMDLs) for petroleum hydrocarbons in the waters of Dutch Harbor and Iliuliuk Harbor in Unalaska, Alaska. Alaska Department of Environmental Conservation, Anchorage, Alaska.
- ADEC. 2013. Alaska's final 2012 Integrated Water Quality Monitoring and Assessment Report. 161 pp.
- ADEC. 2015. Annual Summary of Oil and Hazardous Substance Spills Fiscal Year 2014, Anchorage, Alaska.
- Aerts, L., M. Bleses, S. Blackwell, C. Greene, K. Kim, D. Hannay, and M. Austin. 2008. Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report.
- Aerts, L., and W. J. Richardson. 2009. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2008: Annual Summary Report, Anchorage, AK.
- Aerts, L., and W. J. Richardson. 2010. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2009: Annual Summary Report, Anchorage, AK.
- AEWC. 2018. Bowhead Harest Quota.
- AGDC. 2020a. Application for Incidental Harassment Authorization during construction of the Alaska LNG Project in Prudhoe Bay, Alaska, AKLNG-6010-REG-GRD-REC-00005, Revision No. H, Anchorage, Alaska.
- AGDC. 2020b. Petition for incidental take regulations for construction of the Alaska LNG Project in Cook Inlet, Alaska, AKLNG-6010-REG-GRD-DOC-00001, Revision No. 6, Anchorage, Alaska.
- Alaska Department of Natural Resources. 2014. Division of Oil and Gas: 2014 Annual Report, Juneau, AK.
- Alaska Department of Natural Resources. 2020. Active Oil and Gas Lease Inventory. A. D. o. O. a. Gas, editor.
- Allen, B. M., and R. P. Angliss. 2014. Alaska marine mammal stock assessments, 2013. U.S. Department of Commerce, NOAA Technical Memo. NMFS-AFSC-277:294.
- Allen, S. G. 1984. The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California. *Fishery Bulletin* 82:493-500.
- Alliston, W. G. 1981. The distribution of ringed seals in relation to winter ice-breaking activities in Lake Melville, Labrador, Report from LGL Ltd., St. John's, Newfoundland, for Arctic Pilot Project, Petro-Canada, Calgary, Alberta.
- Andersen, M. S., K. A. Forney, T. V. N. Cole, T. Eagle, R. Angliss, K. Long, L. Barre, L. V. Atta, D. Borggaard, T. Rowles, B. Norberg, J. Whaley, and L. Engleby. 2008. Differentiating serious and non-serious injury of marine mammals: Report of the Serious Injury Technical Workshop, 10-13 September 2007, Seattle, Washington, NOAA Technical Memorandum NMFS-OPR-39. 94 p.

- Anderson, P. J., and J. F. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. *Marine Ecology Progress Series* 189:117-123.
- Army, U. S. 2010. Biological Assessment of the Cook Inlet beluga whale (*Delphinapterus leucas*) for the resumption of year-round firing in Eagle River flats impact area, Fort Richardson, Alaska.
- Au, W. W. L. 2000. Hearing in whales and dolphins: An overview. Pages 1-42 in W. W. L. Au, A. N. Popper, and R. R. Fay, editors. *Hearing by Whales and Dolphins*. Springer-Verlag, New York.
- Au, W. W. L., D. A. Carder, R. H. Penner, and B. L. Scronce. 1985. Demonstration of adaptation in beluga whale echolocation signals *Journal of the Acoustical Society of America* 77(2):726-730.
- Au, W. W. L., A. A. Pack, M. O. Lammers, L. M. Herman, M. H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. *Journal of the Acoustical Society of America* 120(2):1103-1110.
- Austin, M., C. O'Neill, G. Warner, J. Wladichuk, M. Wood, and A. Allen. 2015. Chukchi Sea Analysis and Acoustic Propagation Modeling: Task 3 Deliverable. JASCO Document #01003. Technical report by JASCO Applied Sciences for NMFS.
- Austin, M. E., S. Denes, J. MacDonnell, and G. Warner. 2016. Hydroacoustic Monitoring Report: Anchorage Port Modernization Project Test Pile Program, version 3.0, Technical report by JASCO Applied Sciences for Kiewit Infrastructure West Co. under Contract PSA 2572.
- Awbrey, F. T., J. A. Thomas, and R. A. Kastelein. 1988. Low-frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. *Journal of the Acoustical Society of America* 84(6):2273-2275.
- Bailey, H., B. Senior, D. Simmons, J. Rusin, G. Picken, and P. M. Thompson. 2010. Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. *Marine Pollution Bulletin* 60(6):888-897.
- Bain, D. E., J. C. Smith, R. Williams, and D. Lusseau. 2006. Effects of vessels on behavior of Southern Resident killer whales (*Orcinus* spp). National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- Baker, C. S. 1985. The population structure and social organization of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. University of Hawaii.
- Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. *Oceanographic Literature Review* 9(42):784.
- Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessment: 1996. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California.
- Batten, S. D., D. E. Raitos, S. Danielson, R. Hopcroft, K. Coyle, and A. McQuatters-Gollop. 2018. Interannual variability in lower trophic levels on the Alaskan Shelf. *Deep Sea Research Part II: Topical Studies in Oceanography* 147:58-68.
- Baulch, S., and C. Perry. 2014. Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin* 80(1-2):210-221.
- Beacham, T. D., R. J. Beamish, J. R. Candy, C. Wallace, S. Tucker, J. H. Moss, and M. Trudel. 2014. Stock-specific migration pathways of juvenile sockeye salmon in British Columbia

- waters and in the Gulf of Alaska. *Transactions of the American Fisheries Society* 143(6):1386–1403.
- Becker, P. R., M. M. Krahn, E. A. Mackey, R. Demiralp, M. M. Schantz, M. S. Epstein, M. K. Donais, B. J. Porter, D. C. G. Muir, and S. A. Wise. 2000. Concentrations of Polychlorinated Biphenyls (PCB's), Chlorinated Pesticides, and Heavy Metals and Other Elements in Tissues of Belugas, *Delphinapterus leucas*, from Cook Inlet. *Marine Fisheries Review* 62(3):81-98.
- Becker, P. R., J. Kucklick, J. Houget, J. Keller, J. Reiner, R. Day, and E. A. Mackey. 2010. Current-Use and legacy persistent pollutants in the Cook Inlet beluga whales: results for the analysis of banked tissues from the Alaska Marine Mammal Tissue Archival Project (AMMTAP). Cook Inlet Beluga Whale Science Conference, Anchorage, Alaska.
- Becker, P. R., E. A. Mackey, M. M. Schantz, R. Demiralp, R. R. Greenberg, B. J. Koster, S. A. Wise, and D. C. G. Muir. 1995. Concentrations of Chlorinated Hydrocarbons, Heavy Metals and Other Elements in Tissues Banked by the Alaska Marine Mammal Tissue Archival Project. USDOC, NOAA, NMFS, and USDOC, National Institute of Standards and Technology, Silver Spring, MD.
- Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999–2000. *Polar Biology* 28(11):833-845.
- Bettridge, S., C. S. Baker, J. Barlow, P. Clapham, M. Ford, D. Gouveia, D. Mattila, R. Pace, P. E. Rosel, G. K. Silber, and P. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. N. Department of Commerce, NMFS, SWFSC, editor.
- Blackwell, S., J. W. Lawson, and M. T. Williams. 2004a. Tolerance by ringed seals (*Phoca hispida*) to impact pipediving and construction sounds at an oil production island. *Journal of Acoustical Society of America* 115(5):2346-2357.
- Blackwell, S. B., and C. R. Greene. 2003. Acoustic Measurements in Cook Inlet, Alaska During August 2001. August 12, 2002. Revised June 14, 2003.
- Blackwell, S. B., and C. R. J. Greene. 2005. Underwater and in-air sounds from a small hovercraft. *Journal of Acoustical Society of America* 118(6):6.
- Blackwell, S. B., C. R. G. Jr., and W. J. Richardson. 2004b. Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea. *Journal of Acoustical Society of America* 116(5):3199-3211.
- Blackwell, S. B., J. W. Lawson, and M. T. Williams. 2004c. Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island. *The Journal of the Acoustical Society of America* 115(5):2346-2357.
- Blackwell, S. B., W. J. Richardson, C. R. J. Greene, and B. Streever. 2007. Bowhead whale (*Balaena mysticetus*) migration and calling behavior in the Alaskan Beaufort Sea, Autumn 2001 - 04; An acoustic localization study. *Arctic* 60(3):255 - 270.
- Bockstoce, J. R., D. B. Botkin, A. Philp, B. W. Collins, and J. C. George. 2005. The geographic distribution of bowhead whales, *Balaena mysticetus*, in the Bering, Chukchi, and Beaufort Seas: Evidence from whaleship records, 1849 -1914. *Marine Fisheries Review* 67:1-43.
- Boeker, E. R., and N. E. Schulz. 2010. Examination of the low frequency limit for helicopter noise data in the FAA's Environmental Design Tool and Integrated Noise Model. John A. Volpe National Transportation Systems Center (US).

- BOEM. 2011. Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas. OCS EIS/EA BOEMRE 2011. Alaska Outer Continental Shelf.
- BOEM. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017. Final Programmatic Environmental Impact Statement, OCS EIS/EA BOEM 2012-030. USDOJ, BOEM, Headquarters, Herndon, VA.
- BOEM. 2016a. Cook Inlet Planning Area, Oil and Gas Lease Sale 244. Final Environmental Impact Statement.
- BOEM. 2016b. Outer Continental Shelf Oil and Gas Leasing Program. Final Programmatic Environmental Impact Statement: 2017-2022. OCS EIS/EA BOEM 2016-060. November 2016. <http://boemoceaninfo.com/review/>.
- BOEM. 2016c. Outer Continental Shelf, Oil and Gas Leasing Program: 2017-2022, Final Programmatic Environmental Impact Statement.
- BOEM. 2017a. Final Biological Assessment Oil and Gas Activities Associated with Lease Sale 244. Cook Inlet Beluga, Fin Whale, Humpback Whale, Western Distinct Population Segment of the Steller Sea Lion, and Cook Inlet Beluga and Western Distinct Population Segment of the Steller Sea Lion Critical Habitat. Prepared by: CSA Ocean Sciences Inc. Received February 17, 2017. .
- BOEM. 2017b. Liberty Development and Production Plan Biological Assessment, Anchorage, AK, 235 p.
- BOEM. 2017c. Liberty Development Project Draft Environmental Impact Statement, BOEM 2016-010, Anchorage, AK, 784 p.
- Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. *Geophysical Research Letters* 42(9):3414-3420.
- Born, E. W., F. F. Riget, R. Dietz, and D. Andriashek. 1999. Escape responses of hauled out ringed seals (*Phoca hispida*) to aircraft disturbance. *Polar Biology* 21(3):171-178.
- Boveng, P. L., M. Cameron, P. B. Conn, and E. Moreland. 2017. Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea During the Open-Water Period. , BOEM Report 2016-077.
- Boveng, P. L., and M. F. Cameron. 2013. Pinniped movements and foraging: Seasonal movements, habitat selection, foraging and haul-out behavior of adult bearded seals in the Chukchi Sea. U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Environmental Studies Section, Anchorage, Alaska.
- Bowles, A. E., M. Smultea, B. Würsig, D. P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *The Journal of the Acoustical Society of America* 96(4):2469-2484.
- Boyd, C., R. C. Hobbs, A. E. Punt, K. E. Shelden, C. L. Sims, and P. R. Wade. 2019. Bayesian estimation of group sizes for a coastal cetacean using aerial survey data. *Marine Mammal Science* 35(4):1322-1346.
- Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. *Marine Fisheries Review* 46(4):45-53.
- Braham, H. W. 1991. Endangered whales: A status update. A report on the 5-year status of stocks review under the 1978 amendments to the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory, Seattle, Washington.
- Brandon, J., and P. R. Wade. 2006. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian model averaging. *Journal of Cetacean Research and*

- Management 8(3):225-239.
- Brandt, M. J., A. Diederichs, K. Betke, and G. Nehls. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series* 421:205-216.
- Bratton, G. R., C. B. Spainhour, W. Flory, M. Reed, and K. Jayko. 1993. Presence and Potential Effects of Contaminants. Pages 701-744 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*, volume Special Publication Number 2. The Society for Marine Mammalogy, Lawrence, KS.
- Brenner, R. E., A. R. Munro, and S. J. Larsen. 2019. Run Forecasts and Harvest Projections for 2019 Alaska Salmon Fisheries and Review of the 2018 Season, Anchorage, Alaska.
- Brewer, P. G., and K. Hester. 2009. Ocean acidification and the increasing transparency of the ocean to low-frequency sound. *Oceanography* 22(4):86-93.
- Brodie, P. F. 1993. Noise generated by the jaw actions of feeding fin whales. *Canadian Journal of Zoology* 71(12):2546-2550.
- Brown, J., P. Boehm, L. Cook, J. Trefry, W. Smith, and G. Durell. 2010. cANIMIDA Task 2: Hydrocarbon and metal characterization of sediments in the cANIMIDA study area, Anchorage, Alaska.
- Burek, K. A., F. Gulland, and T. M. O'Hara. 2008. Effects of climate change on Arctic marine mammal health. *Ecological applications* 18(sp2).
- Burgess, W. C. 2014. Ambient underwater sound levels measured at Windy Corner, Turnagain Arm, Alaska. Greeneridge Sciences, Inc. prepared for LGL Alaska Research Associates, Inc., Anchorage, AK.
- Burgess, W. C., S. B. Blackwell, and R. Abbott. 2005. Underwater acoustic measurements of vibratory pile driving at the pipeline 5 crossing in the Snohomish River, Everett, Washington. Greeneridge Report 322-2. Prepared for URS Corporation. 40 pp.
- Burke, B. J., M. C. Liermann, D. J. Teel, and J. J. Anderson. 2013. Environmental and geospatial factors drive juvenile Chinook salmon distribution during early ocean migration. *Canadian Journal of Fisheries and Aquatic Sciences* 70(8):1167-1177.
- Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Juneau, AK.
- Burns, J. J. 1981. Bearded seal *Erignathus barbatus* Erxleben, 1777. *Handbook of Marine Mammals Volume 2: Seals*:145-170.
- Burns, J. J., and T. J. J. Eley. 1976. The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca (Pusa) hispida*). Pages 263-294 in *Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976*, volume 1-Marine Mammals, U.S. Department of Commerce, NOAA, Boulder, CO.
- Burns, J. J., and K. J. Frost. 1979. The natural history and ecology of the bearded seal, *Erignathus barbatus*. (Contract #02-5-002-53):77.
- Burns, J. J., and S. J. Harbo. 1972. An aerial census of ringed seals, northern coast of Alaska. *Arctic* 25(4):279-290.
- Burns, J. J., B. P. Kelly, L. D. Aumiller, K. J. Frost, and S. Hills. 1982. Studies of Ringed Seals in the Alaskan Beaufort Sea during Winter: Impacts of Seismic Exploration Alaska Department of Fish and Game, Fairbanks, AK.
- Burns, J. J., and G. A. Seaman. 1986. Investigations of belukha whales in coastal waters of western and northern Alaska. II. Biology and ecology. U.S. Dept. of Commerce, NOAA, OCSEAP Final Report, pages 221-357

- Calkins, D. G. 1989. Status of beluga whales in Cook Inlet. Pages 109-112 in Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, Anchorage, Alaska.
- CalTrans. 2010. Effects of pile driving sound on juvenile steelhead. Prepared by ICF for Jones & Stokes, Seattle, WA.
- CalTrans. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish: Appendix I – Compendium of Pile Driving Sound Data. Updated November 2015.
- Cameron, M., and P. Boveng. 2007. Abundance and distribution surveys for ice seals aboard USCG Healy and the Oscar Dyson April 10-June 18, 2007.
- Cameron, M., and P. Boveng. 2009. Habitat use and seasonal movements of adult and sub-adult bearded seals. Alaska Fisheries Science Center Quarterly Report October-November-December 2009:1-4.
- Cameron, M., K. J. Frost, Jay M. Ver Hoef, B. G.A., A. V. Whiting, J. Goodwin, and P. L. Boveng. 2018. Habitat selection and seasonal movements of young bearded seals (*Erignathus barbatus*) in the Bering Sea. PLoS One 13(2).
- Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus*). U.S. Department of Commerce, editor, Seattle, WA. .
- Carey, A. G., Jr. , P. H. Scott, and K. W. Walters. 1984. Distributional ecology of shallow southwestern Beaufort Sea (Arctic Ocean) bivalve Mollusca. . Marine Ecology Progress Series 17:124-134.
- Carlens, H., C. Lydersen, B. A. Krafft, and K. M. Kovacs. 2006. Spring haul-out behavior of ringed seals (*Pusa hispida*) in Kongsfjorden, Svalbard. Marine Mammal Science 22(2):379-393.
- Carr, S. A., M. H. Laurinolli, C. D. S. Tollefsen, and S. P. Turner. 2006. Cacouna Energy LNG Terminal: Assessment of Underwater Noise Impacts. Technical report by JASCO Applied Sciences for Golder Associates Ltd, February 8 2006.
- Carstensen, J., O. D. Henriksen, and J. Teilmann. 2006. Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). Marine Ecology Progress Series 321:295-308.
- Casper, B. M., A. N. Popper, F. Matthews, T. J. Carlson, and M. B. Halvorsen. 2012. Recovery of barotrauma injuries in Chinook salmon, *Oncorhynchus tshawytscha* from exposure to pile driving sound. PLoS One 7(6):e39593.
- Castellote, M., T. A. Mooney, L. Quakenbush, R. Hobbs, C. Goertz, and E. Gaglione. 2014. Baseline hearing abilities and variability in wild beluga whales (*Delphinapterus leucas*). Journal of Experimental Biology 217(10):1682-1691.
- Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. Skinner. 2015. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. ADFG Final Report to Department of Defense.
- Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. P. Skinner. 2016. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. Alaska Department of Fish and Game, Final Wildlife Research Report, ADF&G/DWS/WRR-2016-3, Juneau, AK.
- Castellote, M., B. Thayre, M. Mahoney, J. Mondragon, M. Lammers, and R. Small. 2018. Anthropogenic Noise and the Endangered Cook Inlet Beluga Whale, *Delphinapterus*

- leucas: Acoustic Considerations for Management. *Marine Fisheries Review* 80(3):36-88.
- Cate, J. R., M. Brees, M. Larson, R. Simpson, R. Mills, and R. Cooper. 2015 90-Day Report of Marine Mammal Monitoring and Mitigation during a Shallow Geohazard Survey Hilcorp in Foggy Island Bay, Alaska, July 2015.
- Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze. 2014. Ch. 22: Alaska. Pages 514-536 in J. M. Melillo, T. C. Richmond, and G. W. Yohe, editors. *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program.
- Chitre, M., S. H. Ong, and J. Potter. 2005. Performance of coded OFDM in very shallow water channels and snapping shrimp noise. Pages 996-1001 in *IEEE*.
- Citta, J. J., L. T. Quakenbush, J. C. George, R. J. Small, M. P. Heide-Jorgensen, H. Brower, B. Adams, and L. Brower. 2012. Winter Movements of Bowhead Whales (*Balaena mysticetus*) in the Bering Sea. *Arctic* 65(1):13-34.
- Citta, J. J., L. T. Quakenbush, S. R. Okkonen, M. L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J. C. George, H. Brower, R. J. Small, C. J. Ashjian, L. A. Harwood, and M. P. Heide-Jørgensen. 2014. Ecological characteristics of core-use areas used by Bering-Chukchi-Beaufort (BCB) bowhead whales, 2006–2012. *Progress in Oceanography* (0).
- Clapham, P. J. 1993. Social organization of humpback whales on a North Atlantic feeding ground. Pages 131-145 in *in*.
- Clark, C., and G. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. *Journal of Underwater Acoustics (USN)* 52(3):48.
- Clark, C. W. 1998. Acoustic Monitoring of Large Whales to the West of Britain and Ireland Using Bottom-mounted Hydrophone Arrays: October 1996-September 1997. Joint Nature Conservation Committee.
- Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Pages 564-582 in J. A. Thomas, C. F. Moss, and M. Vater, editors. *Echolocation in Bats and Dolphins*. University of Chicago Press.
- Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Marine Ecology Progress Series* 395:201-222.
- Clark, C. W., and J. H. Johnson. 1984. The sounds of the bowhead whale, *Balaena mysticetus*, during the spring migrations of 1979 and 1980. *Canadian Journal of Zoology-Revue Canadienne De Zoologie* 62(7):1436-1441.
- Clarke, J. T., A. A. Brower, C. Christman, and M. C. Ferguson. 2014. Distribution and relative abundance of marine mammals in the Northeastern Chukchi and Western Beaufort Seas, 2013. . A. F. S. C. National Marine Mammal Laboratory, NMFS, NOAA, editor, Seattle, WA.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, A. S. Kennedy, and A. L. Willoughby. 2015a. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2014. A. F. S. C. National Marine Mammal Laboratory, NMFS, NOAA, editor, Seattle, WA.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2017. Distribution and relative abundance of marine mammals in the Eastern Chukchi and Western Beaufort Seas, 2016 Annual Report, OCS Study BOEM 2017-078. A. F. S. C. Marine Mammal

- Laboratory, NMFS NOAA. , editor, Seattle, WA. .
- Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), Alaska OCS Region, Anchorage, AK.
- Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2013. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2012.
- Clarke, J. T., M. C. Ferguson, C. Curtice, and J. Harrison. 2015b. 8. Biologically Important Areas for Cetaceans Within US Waters-Arctic Region. *Aquatic Mammals* 41(1):94.
- Cleator, H. J., I. Stirling, and T. G. Smith. 1989. Underwater vocalizations of the bearded seal (*Erignathus barbatus*). *Canadian Journal of Zoology* 67(8):1900-1910.
- Colbeck, G. J., P. Duchesne, L. D. Postma, V. Lesage, M. O. Hammill, and J. Turgeon. 2013. Groups of related belugas (*Delphinapterus leucas*) travel together during their seasonal migrations in and around Hudson Bay. *Proceedings of the Royal Society B: Biological Sciences* 280(1752):20122552.
- Collier, T. K., C. A. Krone, M. M. Krahn, J. E. Stein, S. L. Chan, and U. Varanasi. 1996. Petroleum exposure and associated biochemical effects in subtidal fish after the Exxon Valdez oil spill. Pages 671-683 in *American Fisheries Society Symposium*.
- Cooke, J. G., O. Sychenko, A. M. Burdin, D. W. Weller, A. L. Bradford, A. R. Lang, and R. L. Brownell, Jr. . 2019. Population Assessment Update for Sakhalin Gray Whales. SC/68A/CMP/21, Presentation of the Western Gray Whale Advisory Committee to the International Whaling Commission Scientific Committee. Nairobi, Kenya, May 2019.
- Council of Canadian Academies. 2016. Commercial marine shipping accidents: understanding the risks in Canada. Ottawa (ON); Workshop report. (ISBN: 978-1-926522-18-0).
- Cowan, D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.
- Cowan, D. F., and B. E. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. *Journal of Comparative Pathology* 139(1):24-33.
- Crane, P. A., W. D. Templin, D. M. Eggers, and L. W. Seeb. 2000. Genetic stock identification of southeast Alaska Chinook salmon fishery catches. Final report submitted to U.S. Chinook Technical Committee by Alaska Department of Fish and Game. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J00-01, Anchorage, Alaska.
- Cranford, T. W., M. Amundin, and K. S. Norris. 1996. Functional morphology and homology in the odontocete nasal complex: Implications for sound generation. *Journal of Morphology* 228(3):223-285.
- Cranford, T. W., and P. Krysl. 2015. Fin whale sound reception mechanisms: skull vibration enables low-frequency hearing. *PLoS One* 10(1):e0116222.
- Crawford, J. A., K. J. Forst, L. Quakenbush, and A. Whiting. 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. *Polar Biology* 35:241-255.
- Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison, and B. R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales.

- Animal Conservation 4(1):13-27.
- Crowley, T. J. 2000. Causes of climate change over the past 1000 years. *Science* 289(5477):270-277.
- Cummings, W. C., D. V. Holliday, and B. J. Lee. 1986. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. NOAA, Anchorage, AK.
- Curry, B. E., and E. F. Edwards. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean: Research planning. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
- Dähne, M., A. Gilles, K. Lucke, V. Peschko, S. Adler, K. Krügel, J. Sundermeyer, and U. Siebert. 2013. Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. *Environmental Research Letters* 8(2):025002.
- Daly, E. A., J. A. Scheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman, and J. A. Miller. 2014. Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River estuary, plume, and coastal waters. *Marine and Coastal Fisheries* 6(1):62–80.
- Deecke, V. B., P. J. Slater, and J. K. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. *Nature* 420(6912):171.
- Dehn, L. A., G. Sheffield, E. H. Follmann, L. K. Duffy, D. L. Thomas, G. R. Bratton, R. J. Taylor, and T. M. O'Hara. 2005. Trace elements in tissues of phocid seals harvested in the Alaskan and Canadian Arctic: Influence of age and feeding ecology. *Canadian Journal of Zoology* 83:726-746.
- Dehnhardt, G., B. Mauck, and H. Bleckmann. 1998. Seal whiskers detect water movements. *Nature* 394(6690):235-236.
- Derocher, A. E., N. J. Lunn, and I. Stirling. 2004. Polar bears in a warming climate. (*Ursus maritimus*). *Integrative and Comparative Biology* 44(2):163-176.
- Dickerson, C., K. J. Reine, and D. G. Clarke. 2001. Characterization of underwater sounds produced by bucket dredging operations. DOER Technical Notes Collection. ERDC TN-DOER-E14. Vicksburg, MS: U.S. Army Engineer Research and Development Center. .
- Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate change impacts on marine ecosystems. *Annual Reviews in Marine Science* 4:11-37.
- Dunlop, R. A., D. H. Cato, and M. J. Noad. 2014. Evidence of a Lombard response in migrating humpback whales (*Megaptera novaeangliae*). *The Journal of the Acoustical Society of America* 136(1):430-437.
- Dunton, K. H., T. Weingartner, and E. C. Carmack. 2006. The nearshore western Beaufort Sea ecosystem: Circulation and importance of terrestrial carbon in arctic coastal food webs. *Progress in Oceanography* 71:362-378.
- Eaton, R. L. 1979. A beluga whale imitates human speech. *Carnivore* 2:22-23.
- Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. *Bioacoustics* 8:47-60.
- Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence Estuary. *Bioacoustics* 1(2-3):131-149.
- Edrén, S. M. C., S. M. Andersen, J. Teilmann, J. Carstensen, P. B. Harders, R. Dietz, and L. A. Miller. 2010. The effect of a large Danish offshore wind farm on harbor and gray seal haul-out behavior. *Marine Mammal Science* 26(3):614-634.

- Efroymson, R. A., and G. W. Suter. 2001. Ecological risk assessment framework for low-altitude aircraft overflights: II. Estimating effects on wildlife. *Risk Analysis* 21(2):263-274.
- Eley, W. D. 2012. Cook Inlet vessel traffic study. Report to Cook Inlet Risk Assessment Advisory Panel. Cape International, Juneau, AK.
- Ellison, W., B. Southall, C. Clark, and A. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology* 26(1):21-28.
- Ellison, W. T., C. W. Clark, and G. C. Bishop. 1987. Potential Use of Surface Reverberation by Bowhead Whales, *Balaena mysticetus*, in Under-ice Navigation: Preliminary Considerations. Report of the International Whaling Commission 37:329-332.
- Elsner, R., D. Wartzok, N. B. Sonafrank, and B. P. Kelly. 1989. Behavioral and physiological reactions of arctic seals during under-ice pilotage. *Canadian Journal of Zoology* 67(10):2506-2513.
- EPA. 2015. Permit No. AKG 28 5100. Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) for Oil and Gas Exploration Facilities in Federal Waters of Cook Inlet.
- Erbe, C. 2002. Hearing Abilities of Baleen Whales. Defense Research and Development Canada, Ottawa, Ont.
- Everitt, R., C. Fiscus, and R. DeLong. 1980. Northern Puget Sound marine mammals. Interagency energy/environment R&D Program Report. EPA 600/7-80-139. Prepared for the US EPA, Washington, DC.
- Ezer, T., J. R. Ashford, C. M. Jones, B. A. Mahoney, and R. C. Hobbs. 2013. Physical–biological interactions in a subarctic estuary: How do environmental and physical factors impact the movement and survival of beluga whales in Cook Inlet, Alaska? *Journal of Marine Systems* 111:120-129.
- Fabry, V. J., J. B. McClintock, J. T. Mathis, and J. M. Grebmeier. 2009. Ocean acidification at high latitudes: the Bellweather. *Oceanography* 22(4):160-171.
- Fabry, V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science* 65:414-432.
- Fay, F. H., J. L. Sease, and R. L. Merrick. 1990. Predation on a ringed seal, *Phoca hispida*, and a black guillemot, *Cephus grylle*, by a Pacific walrus, *Odobenus rosmarus divergens*. *Marine Mammal Science* 6(4):348-350.
- Fay, V. 2002. Alaska Aquatic Nuisance Species Management Plan. Alaska Department of Fish and Game Publication. Juneau, AK.
- Federal Aviation Administration. 2016. Alaskan Region Aviation Fact Sheet.
- Fedoseev, G. A. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. *Izvestiya TINRO* 65:212-216.
- Fedoseev, G. A. 1971. The distribution and numbers of seals on whelping and moulting patches in the Sea of Okhotsk. Pages 87-99 in K. K. Chapskii, and E. S. Milchenko, editors. *Research on Marine Mammals*, volume 39. Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), Kaliningrad, Russia.
- Fedoseev, G. A. 1984. Population structure, current status, and perspective for utilization of the ice-inhabiting forms of pinnipeds in the northern part of the Pacific Ocean. Pages 130-146 in A. V. Yablokov, editor. *Marine mammals*. Nauka, Moscow.
- Feely, R. A., S. C. Doney, and S. R. Cooley. 2009. Ocean acidification: present conditions and future changes in a high-CO₂ world. *Oceanography* 22(4):37-47.

- Feltz, E. T., and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. *Cryobiology* 3:261-264.
- FERC. 2019. Alaska LNG Project: Draft Environmental Impact Statement, FERC/EIS-0296D, Washington, D.C.
- Ferguson, M. C., and J. T. Clarke. 2013. Estimates of detection probability for BWASP bowhead whale, gray whale, and beluga sightings collected from Twin Otter and Aero Commander aircraft, 1989 to 2007 and 2008 to 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-261, 52 pgs.
- Ferguson, M. C., C. Curtice, and J. Harrison. 2015a. 6. Biologically Important Areas for Cetaceans Within US Waters-Gulf of Alaska Region. *Aquatic Mammals* 41(1):65.
- Ferguson, M. C., J. M. Waite, C. Curtice, J. T. Clarke, and J. Harrison. 2015b. 7. Biologically Important Areas for Cetaceans Within US Waters-Aleutian Islands and Bering Sea Region. *Aquatic Mammals* 41(1):79.
- Finley, K. J., and W. E. Renaud. 1980. Marine mammals inhabiting the Baffin Bay North Water in winter. *Arctic* 33(4):724-738.
- Finneran, J. J., D. A. Carder, R. Dear, T. Belting, J. McBain, L. Dalton, and S. H. Ridgway. 2005. Pure tone audiograms and possible aminoglycoside-induced hearing loss in belugas (*Delphinapterus leucas*). *Journal of the Acoustical Society of America* 117(6):3936-3943.
- Finneran, J. J., D. A. Carder, and S. H. Ridgway. 2003. Temporary Threshold Shift (TTS) measurements in bottlenose dolphins (*Tursiops truncatus*), belugas (*Delphinapterus leucas*), and California sea lions (*Zalophus californianus*). Pages 12-16 in *Environmental Consequences of underwater Sound (ECOUS) Symposium*, San Antonio Texas.
- Finneran, J. J., and C. E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). *The Journal of the Acoustical Society of America* 133(3):1819-1826.
- Finneran, J. J., C. E. Schlundt, D. A. Carder, and S. H. Ridgway. 2002a. Auditory filter shapes for the bottlenose dolphin (*Tursiops truncatus*) and the white whale (*Delphinapterus leucas*) derived with notched noise. *The Journal of the Acoustical Society of America* 112(1):322-328.
- Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder, and S. H. Ridgway. 2002b. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *The Journal of the Acoustical Society of America* 111(6):2929-2940.
- Fischer, J. B. 1829. *Synopsis Mammalium*, 1829. *Bos maschatus fossilis*:494.
- Fiscus, C. H., and G. A. Baines. 1966. Food and Feeding Behavior of Steller and California Sea Lions. *Journal of Mammalogy* 47(2):195-200.
- Fisher, J. P., L. A. Weitkamp, D. J. Teel, S. A. Hinton, J. A. Orsi, E. V. Farley, J. F. T. Morris, M. E. Thiess, R. M. Sweeting, and M. Trudel. 2014. Early ocean dispersal patterns of Columbia River Chinook and coho salmon. *Transactions of the American Fisheries Society* 143(1):252-272.
- Fisheries Hydroacoustic Working Group. 2008. Agreement in Principal for Interim Criteria for Injury to Fish from Pile Driving Activities . Memorandum signed June 12, 2008.
- Forney, K. A., B. L. Southall, E. Slooten, S. Dawson, A. J. Read, R. W. Baird, and R. L. Brownell Jr. 2017. Nowhere to go: noise impact assessments for marine mammal populations with high site fidelity. *Endangered Species Research* 32:391-413.

- Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6):305-313.
- Freitas, C., K. M. Kovacs, R. A. Ims, M. A. Fedak, and C. Lydersen. 2008. Ringed seal post-moulting movement tactics and habitat selection. *Oecologia* 155(1):193-204.
- Frid, A., and L. M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. 6(1): 11. [online] URL: . *Conservation Ecology* 6(1):1-16.
- Friday, N. A., A. N. Zerbini, J. M. Waite, S. E. Moore, and P. J. Clapham. 2013. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf, June and July of 2002, 2008, and 2010. *Deep Sea Research Part II: Topical Studies in Oceanography* 94:244-256.
- Friedlaender, A. S., E. L. Hazen, D. P. Nowacek, P. N. Halpin, C. Ware, M. T. Weinrich, T. Hurst, and D. Wiley. 2009. Diel changes in humpback whale *Megaptera novaeangliae* feeding behavior in response to sand lance *Ammodytes* spp. behavior and distribution. *Marine Ecology Progress Series* 395:91-100.
- Fristrup, K. M., L. T. Hatch, and C. W. Clark. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. *The Journal of the Acoustical Society of America* 113(6):3411-3424.
- Frost, K. J., and J. J. Burns. 1989. Winter Ecology of Ringed Seals (*Phoca hispida*) in Alaska
- Frost, K. J., and L. F. Lowry. 1981. Ringed, Baikal and Caspian seals. *Handbook of marine mammals* 2:29-54.
- Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea. P. W. Barnes, D. M. Schell, and E. Reimnitz, editors. *The Alaskan Beaufort Sea: Ecosystems and Environments*. Academic Press, Inc., New York, NY.
- Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2002. Monitoring distribution and abundance of ringed seals in northern Alaska, Juneau, AK.
- Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. *Arctic* 57(2):115-128.
- Frost, K. J., A. Whiting, M. F. Cameron, and M. A. Simpkins. 2008. Habitat use, seasonal movements and stock structure of bearded seals in Kotzebue Sound, Alaska. Tribal Wildlife Grants Program, Fish and Wildlife Service, Anchorage, AK.
- Frouin-Mouy, H., D. Zeddies, and M. Austin. 2016. Passive Acoustic Monitoring Study: Hilcorp's 2015 Geohazard Survey in Foggy Island Bay, AK.
- Fukuyama, A., G. Gillingham, and I. Hartwell. 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Benthic Infaunal Communities. Conference paper.
- Funk, D., D. Hannay, D. Ireland, R. Rodrigues, and W. R. Koski. 2008. Marine mammal monitoring during open water seismic exploration by Shell Offshore, Inc. in the Chukchi and Beaufort Seas, July-November 2007: 90 day report. LGL Alaska Research Assoc., Inc., Anchorage, AK.
- Funk, D. W., T. M. Markowitz, and R. Rodrigues. 2005. Baseline studies of beluga whale habitat use in Knik Arm, Upper Cook Inlet, Alaska, July 2004-July 2005. Rep. from LGL Alaska Research Associates, Inc., Anchorage, AK, in association with HDR Alaska, Inc., Anchorage, AK, for the Knik Arm Bridge and Toll Authority, Anchorage, AK, the Department of Transportation and Public Facilities, Anchorage, AK, and the Federal

- Highway Administration, Juneau, AK.
- Funk, D. W., R. Rodrigues, D. S. Ireland, and W. R. Koski. 2010. Summary and assessment of potential effects on marine mammals. Pages 11-1 - 11-59 in I. D. Funk DW, Rodrigues R, and Koski WR, editor. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008, volume LGL Alaska Report P1050-2.
- Gaden, A., S. H. Ferguson, L. Harwood, H. Melling, and G. A. Stern. 2009. Mercury trends in ringed seals (*Phoca hispida*) from the western Canadian Arctic since 1973: associations with length of ice-free season. *Environ Sci Technol* 43(10):3646-51.
- Gailey, G., B. Würsig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134(1-3):75.
- Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pages 171-192 in S. Ridgway, and R. Harrison, editors. *Handbook of marine mammals*, volume 3. Academic Press, London, UK.
- Garber-Yonts, B., and J. Lee. 2017. Economic status report summary: BSAI crab fisheries, 2017. Appendix to the 2017 Final Stock Assessment and Fishery Evaluation report for the king and tanner crab fisheries of the Bering Sea and Aleutian Islands Regions Pages 1620 p. in. North Pacific Fishery Management Council, Anchorage, AK.
- Gardiner, K. J., and A. J. Hall. 1997. Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). *Canadian Journal of Zoology* 75(11):1773-1780.
- Garland, E. C., M. Castellote, and C. L. Berchok. 2015. Beluga whale (*Delphinapterus leucas*) vocalizations and call classification from the eastern Beaufort Sea population. *Journal of the Acoustical Society of America* 137(6):3054-3067.
- Gende, S., L. Vose, J. Baken, C. Gabriele, R. Preston, and A. N. Hendrix. 2019. Active whale avoidance by large ships: components and constraints of a complementary approach to reducing ship strike risk. *Frontiers in Marine Science* 6:592.
- George, J., M. L. Druckenmiller, K. L. Laidre, R. Suydam, and B. Person. 2015a. Bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. *Progress in Oceanography* 136:250-262.
- George, J. C., C. Clark, G. M. Carroll, and W. T. Ellison. 1989. Observations on the Ice-Breaking and Ice Navigation Behavior of Migrating Bowhead Whales (*Balaena mysticetus*) near Point Barrow, Alaska, Spring 1985. *Arctic* 42(1):24-30.
- George, J. C., M. L. Druckenmiller, K. L. Laidre, R. Suydam, and B. Person. 2015b. Bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. *Progress in Oceanography* 136:250-262.
- George, J. C., G. H. Givens, J. Herreman, R. A. Delong, B. Tudor, R. Suydam, and L. Kendall. 2011. Report of the 2010 bowhead whale survey at Barrow with emphasis on methods for matching sightings from paired independent observations. IWC Scientific Committee, Tromso, Norway.
- George, J. C., C. Nicolson, S. Drobot, J. Maslanik, and R. Suydam. 2006. Sea ice density and bowhead whale body condition preliminary findings [Poster] Society for Marine Mammalogy, San Diego, CA.
- George, J. C., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayer, B. T. Person, T. Sformo, and R. Suydam. 2017. Frequency of Injuries from Line Entanglements, Killer Whales, and Ship Strikes on Bering-Chukchi-Beaufort Seas Bowhead Whales. *Arctic* 70(1):37-46.

- George, J. C., J. E. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western arctic bowhead whales surveyed near Barrow, Alaska. *Marine Mammal Science* 20:755-773.
- Geraci, J. R. 1990. Physiologic and Toxic Effects on Cetaceans. Pages 167-197 in J. R. Geraci, and D. J. St. Aubin, editors. *Sea Mammals and Oil: Confronting the Risks*. Academic Press, Inc., and Harcourt Brace Jovanovich, San Diego, CA.
- Geraci, J. R., D. M. Anderson, R. J. Timperi, D. J. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. *Canadian Journal of Fisheries and Aquatic Sciences* 46(11):1895-1898.
- Geraci, J. R., and D. J. St. Aubin. 1990. *Sea Mammals and Oil: Confronting the Risks*. Academic Press, Inc., San Deigo, CA.
- Givens, G. H., S. L. Edmondson, J. C. George, R. Suydam, R. A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R. A. DeLong, and C. W. Clark. 2013. Estimate of 2011 abundance of the Bering-Chukchi-Beaufort Seas bowhead whale population. Paper SC/65a/BRG01 (Scientific Committee of the International Whaling Commission 65a, Jeju Island, Korea).
- Gjertz, I., K. M. Kovacs*, C. Lydersen*, and O. Wiig. 2000. Movements and diving of bearded seal (*Erignathus barbatus*) mothers and pups during lactation and post-weaning. *Polar Biology* 23(8):559-566.
- Goetz, K. T., R. A. Montgomery, J. M. Ver Hoef, R. C. Hobbs, and D. S. Johnson. 2012. Identifying essential summer habitat of the endangered beluga whale *Delphinapterus leucas* in Cook Inlet, Alaska. *Endangered Species Research* 16(2):135-147.
- Goldbogen, J. A., J. Calambokidis, D. A. Croll, J. T. Harvey, K. M. Newton, E. M. Oleson, G. Schorr, and R. E. Shadwick. 2008. Foraging behavior of humpback whales: kinematic and respiratory patterns suggest a high cost for a lunge. *Journal of Experimental Biology* 211(23):3712-3719.
- Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald, and J. A. Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209(7):1231-1244.
- Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. P. Simmonds, R. Swift, and D. Thompson. 2003. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal* 37(4):16-34.
- Götz, T., and V. M. Janik. 2011. Repeated elicitation of the acoustic startle reflex leads to sensitisation in subsequent avoidance behaviour and induces fear conditioning. *BMC neuroscience* 12(1):30.
- Gray, L. M., and D. S. Greeley. 1980. Source level model for propeller blade rate radiation for the world's merchant fleet. *The Journal of the Acoustical Society of America* 67(2):516-522.
- Green, G. A., K. Hashagen, and D. Lee. 2007. Marine mammal monitoring program, FEX barging project, 2007. Report prepared by Tetra Tech EC, Inc., Bothell WA, for FEX LP, Anchorage, AK.
- Green, G. A., and S. Negri. 2005. Marine mammal monitoring program, FEX barging project, 2005. ASRC Lynx Enterprises Inc. , Bothell, Washington
- Green, G. A., and S. Negri. 2006. Marine Mammal Monitoring Program, FEX Barging Project, 2006. ASRC lynx Enterprises Inc. , Bothell, WA.

- Greene, C. R. 1981. Underwater Acoustic Transmission Loss and Ambient Noise in Arctic Regions. Pages 234-258 in N. M. Peterson, editor The Question of Sound from Icebreaker Operations, Proceedings of a Workshop. Canada: Arctic Pilot Project, Petro-Canada, Toronto, Ont., Canada.
- Greene, C. R., and S. E. Moore. 1995. Man-made noise. Pages 101-158 in W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.
- Greene, C. R., and W. J. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. Journal of the Acoustical Society of America 83(6):2246-2254.
- Hain, J., R. Carter, D. Kraus, A. Mayo, and E. Winni. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. Fishery Bulletin 80(2).
- Hain, J. H. W., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-669.
- Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2012. Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. PLoS One 7(6):e38968.
- Hansen, D. J. 1985. The Potential Effects of Oil Spills and Other Chemical Pollutants on Marine Mammals Occurring in Alaskan Waters. USDOJ, MMS, Alaska OCS Region, Anchorage, AK.
- Hare, S. R., and N. J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47:103-145.
- Harris, R. E., G. W. Miller, and W. J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4):795-812.
- Harrison, C. S., and J. D. Hall. 1978. Alaskan distribution of beluga whale, *Delphinapterus leucas*. Canadian Field-Naturalist 92(3):235-241.
- Hart Crowser Inc., Pentec Environmental, and Illingworth & Rodkin. 2009. Acoustic Monitoring and In-situ Exposures of Juvenile Coho Salmon to Pile Driving Noise at the Port of Anchorage Marine Terminal Redevelopment Project Knik Arm, Anchorage, Alaska. Prepared for URS Corporation. October 2009 12684-03. 72 pp.
- Harwood, L. A., T. G. Smith, and J. C. Auld. 2012. Fall migration of ringed seals (*Phoca hispida*) through the Beaufort and Chukchi seas, 2001-02. Arctic 65:35-44.
- Harwood, L. A., T. G. Smith, J. C. Auld, H. Melling, and Yurkowski. 2015. Seasonal movements and diving of ringed seals, *Pusa hispida*, in the western Canadian Arctic, 1999-2001 and 2010-11. Arctic 68(2):193-209.
- Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology-Revue Canadienne De Zoologie 70(5):891-900.
- Hastings, M. C., and A. N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Sacramento, California.
- Hatch, L. T., C. W. Clark, S. M. Van Parijs, A. S. Frankel, and D. W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a US National Marine Sanctuary. Conservation Biology 26(6):983-994.
- Hauser, D. D. W., V. D. Moulton, K. Christie, C. Lyons, G. Warner, C. O'Neill, D. Hannay, and S. Inglis. 2008. Marine mammal and acoustic monitoring of the Eni/PGS open-water

- seismic program near Thetis, Spy and Leavitt islands, Alaskan Beaufort Sea, 2008: 90-day report.
- Hawkins, A. D., A. E. Pembroke, and A. N. Popper. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. *Reviews in Fish Biology and Fisheries* 25:39-64.
- Hayes, S. A., and J. F. Kocik. 2014. Comparative estuarine and marine migration ecology of Atlantic salmon and steelhead: blue highways and open plains. *Reviews in Fish Biology and Fisheries* 24(3):757-780.
- Helweg, D. A., D. S. Houser, and P. W. Moore. 2000. An integrated approach to the creation of a humpback whale hearing model. SPACE AND NAVAL WARFARE SYSTEMS CENTER SAN DIEGO CA.
- Henry, E., and M. O. Hammill. 2001. Impact of small boats on the haulout activity of harbour seals (*Phoca vitulina*) in Metis Bay, Saint Lawrence Estuary, Quebec, Canada. *Aquatic Mammals* 27(2):140-148.
- Heptner, L. V. G., K. K. Chapskii, V. A. Arsenov, and V. T. Sokolov. 1976. Bearded seal. *Erignathus barbatus* (Erxleben, 1777). Pages 166-217 in L. V. G. Heptner, N. P. Naumov, and J. Mead, editors. *Mammals of the Soviet Union. Volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti, volume 2, Part 3.* Vysshaya Shkola Publishers, Moscow, Russia.
- Herráez, P., E. Sierra, M. Arbelo, J. Jaber, A. E. De Los Monteros, and A. Fernández. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. *Journal of Wildlife Diseases* 43(4):770-774.
- Hezel, P. J., X. Zhang, C. M. Bitz, B. P. Kelly, and F. Massonnet. 2012. Projected decline in spring snow depth on Arctic sea ice caused by progressively later autumn open ocean freeze-up this century. *Geophysical Research Letters* 39(L17505).
- Hickie, J., and S. Herrero. 1983. Distribution and movements of bowhead whales and other marine mammals in the Prudhoe Bay region, Alaska, 26 September to 13 October 1982. Pages 84-117 in B. J. Gallaway, editor. *Biological studies and monitoring at Seal Island, Beaufort Sea, Alaska 1982.* Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for Shell Oil Co., Houston, TX. 150 p.
- Hilcorp. 2017. Weekly Reports, Middle Ground Shoal Platform Natural Gas Pipeline Release, May-June 2017. .
- Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395:5-20.
- Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subArctic Alaskan estuary. *Arctic* 58(4):331-340.
- Hobbs, R. C., and K. E. W. Sheldon. 2008. Supplemental status review and extinction assessment of Cook Inlet belugas (*Delphinapterus leucas*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.
- Hobbs, R. C., C. L. Sims, and K. E. W. Sheldon. 2012. Estimated abundance of belugas in Cook Inlet, Alaska, from aerial surveys conducted in June 2012. Unpublished report. National Marine Fisheries Service, National Marine Mammals Laboratory.
- Holliday, D. V., W. C. Cummings, and D. E. Bonnett. 1983. Sound and vibration levels in a ringed seal lair from seismic profiling on the ice in the Beaufort Sea. *Journal of the*

- Acoustical Society of America 74(S1):S54.
- Hollowed, A. B., and W. S. Wooster. 1992. Variability of Winter Ocean Conditions and Strong Year Classes of Northeast Pacific Groundfish. ICES Marine Science Symposium 195:433-444.
- Holst, M., I. Stirling, and K. A. Hobson. 2001. Diet of ringed seals (*Phoca hispida*) on the east and west sides of the North Water Polynya, northern Baffin Bay. Marine Mammal Science 17(4):888-908.
- Holsvik, R. 1998. Maternal behaviour and early behavioural ontogeny of bearded seals (*Erignathus barbatus*) from Svalbard, Norway. Masters Thesis. Norwegian University of Science and Technology, Trondheim, Norway.
- Hoover, A. A. 1988. Harbor seal (*Phoca vitulina*). Pages 125-157 in J. W. Lentfer, editor. Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, D.C.
- Hossain, K., T. Koivurova, and G. Zojer. 2014. Understanding risks associated with offshore hydrocarbon development. Pages 159-176 in Arctic Marine Governance. Springer.
- Houghton, J. 2001. The science of global warming. Interdisciplinary Science Reviews 26(4):247-257.
- Houghton, J., J. Starkes, M. Chambers, and D. Ormerod. 2005a. 2004-2005 marine fish and benthos studies-Port of Anchorage, Anchorage, Alaska. Report prepared by Pentec Environmental, Edmonds, WA, for Integrated Concepts and Research Corporation.
- Houghton, J., J. Starkes, M. Chambers, and D. Ormerod. 2005b. Marine fish and benthos studies in Knik Arm, Anchorage, Alaska. Report prepared by Pentec Environmental, Edmonds, Washington for Knik Arm Bridge and Toll Authority, Anchorage, Alaska, and HDR Alaska, Inc., Anchorage, Alaska
- Houser, D. S., G.-R. A., and J. J. Finneran. 2008. Evoked potential audiometry of 13 Pacific bottlenose dolphins (*Tursiops truncatus gilli*). Marine Mammal Science 24:28-41.
- Houser, D. S., and J. J. Finneran. 2006. Variation in the hearing sensitivity of a dolphin population determined through the use of evoked potential audiometry. Journal of Acoustical Society of America 120:4090-4099.
- Houser, D. S., D. A. Helweg, and P. W. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27(2):82-91.
- Hunt, K. E., R. M. Rolland, S. D. Kraus, and S. K. Wasser. 2006. Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and comparative endocrinology 148(2):260-272.
- Huntington, H. P. 2000a. Traditional ecological knowledge of seals in Norton Bay, Alaska. Elim-Shaktoolik-Koyuk Marine Mammal Commission and the National Marine Fisheries Service.
- Huntington, H. P. 2000b. Using traditional ecological knowledge in science: methods and applications. Ecological applications 10(5):1270-1274.
- Hyvärinen, H. 1989. Diving in darkness: whiskers as sense-organs of the Ringed Seal (*Phoca hispida saimensis*). Journal of Zoology 218(4):663-678.
- ICCT. 2015. A 10-Year Projection of Maritime Activity in the U.S. Arctic Region. Contracted and coordinated under the U.S. Committee of the Marine Transportation System. Prepared by the International Council on Clean Transportation. Washington, DC. .
- Ice Seal Committee. 2016. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2014.

- Ice Seal Committee. 2017. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2015.
- ICRC. 2009. Marine Mammal Monitoring Final Report: 15 July 2008 through 14 July 2009. Construction and scientific monitoring associated with the Port of Anchorage Marine Terminal Redevelopment Project. , Anchorage, AK.
- Illingworth & Rodkin. 2007. Compendium of pile driving sound data. Prepared for the California Department of Transportation. 129 p.
- Illingworth & Rodkin, I. 2013. Naval Base Kitsap at Bangor, Trident Support Facilities Explosive Handling Wharf (EHW-2) Acoustic Monitoring Report. Prepared by Illingworth & Rodkin. April 2013. Bangor, Washington. 165 pp.
- Illingworth & Rodkin, I. 2014. Anchorage Port modernization project, underwater noise monitoring plan. Prepared for CH2M Hill Engineers, Inc., Project No. 14-141. 43 pp.
- Ilyashenko, V. U. 2013. Aboriginal harvest of gray and bowhead whales in the Russian federation in 2008 – 2012. IWC Scientific Committee.
- Ilyashenko, V. U., and K. Zharijov. 2014. Aboriginal harvest of gray and bowhead whales in the Russian federation in 2013. IWC Scientific Committee.
- Ilyashenko, V. U., and K. Zharijov. 2015. Aboriginal subsistence whaling in the Russian federation in 2014. Pages 5 *in*. IWC Scientific Committee.
- IPCC. 2013. Summary for policymakers. Pages 3-39. Pages 3-39 *in* D. Q. T. F. Stocker, G. K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editor. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- IPCC. 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC, Geneva, Switzerland.
- IPCC. 2019. Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.).
- Ireland, D. S., and L. N. Bisson. 2016. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi Sea, July–October 2015: 90-Day Report. LGL Rep. P1363D. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Gulf of Mexico Inc, Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 188 pp, plus appendices.
- Isaac, J. L. 2009. Effects of climate change on life history: implications for extinction risk in mammals. *Endangered Species Research* 7(2):115-123.
- IWC. 2008. Annex F: Report of the sub-committee on bowhead, right and gray whales. International Whaling Commission.
- IWC. 2009. Annex F: Report of the sub-committee on bowhead, right and gray Whales. International Whaling Commission.
- IWC. 2010. Annex F: Report of the sub-committee on bowhead, right and gray whales. International Whaling Commission.
- IWC. 2011. Report of the scientific committee. IWC.

- IWC. 2012. Annex F: Report of the sub-committee on bowhead, right and gray whales. J. Cetacean Res. Manage. 13 (Suppl.):154-174.
- Jacobs Engineering. 2017. Biological Evaluation for Offshore Oil and Gas Exploratory Drilling in the Kitchen Lights Unit of Cook Inlet, Alaska. Developed for Furie Operating Alaska, LLC. .
- Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtson. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74(6):1186-1194.
- Jensen, A., M. Williams, L. Jemison, and K. Raum-Suryan. 2009. Somebody untangle me! Taking a closer look at marine mammal entanglement in marine debris. Pages pp. 63-69 in M. Williams, and E. Ammann, editors. Marine Debris in Alaska: coordinating our efforts, volume 09-01. Alaska Sea Grant College Program, University of Alaska Fairbanks.
- Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. . N. T. M. N.-O. U.S. Department of Commerce, editor.
- Jewett, S. C., T. A. Dean, B. R. Woodin, M. K. Hoberg, and J. J. Stegeman. 2002. Exposure to hydrocarbons 10 years after the Exxon Valdez oil spill: evidence from cytochrome P4501A expression and biliary FACs in nearshore demersal fishes. Marine Environmental Research 54(1):21-48.
- Jiang, L., R. A. Feely, B. R. Carter, D. J. Greeley, D. K. Gledhill, and K. M. Arzayus. 2015. Climatological distribution of aragonite saturation state in the global oceans. Global Biogeochemical Cycles 29:1656-1673.
- Jiang, M., L. Li, Y. Li, G. Shen, and X. Shen. 2017. Oxidative stress in shellfish *Sinonovacula constricta* exposed to the water accommodated fraction of zero sulfur diesel oil and pinghu crude oil. Archives of environmental contamination and toxicology 73(2):294-300.
- Johnson, C. S. 1967. Sound detection thresholds in marine mammals. Pages 247-260 in W. N. Tavolga, editor. Marine bioacoustics. Lerner Marine Laboratory, Pergamon Press, Bimini, Bahamas.
- Johnson, C. S., M. W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustical Society of America 85(6):2651-4.
- Johnson, J. H., and A. A. Wolman. 1984. The Humpback Whale, *Megaptera novaeangliae*. Marine Fisheries Review 46(4):300-337.
- Jones, J. M., B. J. Thayre, E. H. Roth, M. Mahoney, I. Sia, K. Mercurief, C. Jackson, C. Zeller, M. Clare, A. Bacon, S. Weaver, Z. Gentes, R. J. Small, I. Stirling, S. M. Willins, and J. A. Hildebrand. 2014. Ringed, Bearded, and Ribbon Seal Vocalizations North of Barrow, Alaska: Seasonal Presence and Relationship with Sea Ice. Arctic 67:203-222.
- KABATA. 2004. Knik Arm Crossing preliminary offshore water quality assessment. Kinnetic Laboratories, Inc.
- Kajimura, H., and T. R. Loughlin. 1988. Marine mammals in the oceanic food web of the eastern subarctic Pacific. Bulletin of the Ocean Research Institute-University of Tokyo.
- Kato, H., and T. Miyashita. 1998. Current status of North Pacific sperm whales and its preliminary abundance estimates. Unpublished report submitted to Int. Whal. Comm. (SC/50/CAWS/52). 6 pp.
- Kawamura, A. 1980. A review of food of balaenopterid whales. Sci. Rep. Whales Res. Inst 32:155-197.
- Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and

- P. Boveng. 2010a. Seasonal home ranges and fidelity to breeding sites among ringed seals. *Polar Biology* 33(8):1095-1109.
- Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010b. Status review of the ringed seal (*Phoca hispida*). U.S. Department of Commerce, Seattle, WA.
- Kelly, B. P., O. R. Harding, M. Kunnsranta, L. Quakenbush, and B. D. Taras. 2005. Correction factor for ringed seal surveys in Northern Alaska, Final Report.
- Kelly, B. P., L. Quakenbush, and J. R. Rose. 1986. Ringed seal winter ecology and effects of noise disturbance. Institute of Marine Science, Fairbanks, Alaska.
- Kelly, B. P., and L. T. Quakenbush. 1990. Spatiotemporal use of lairs by ringed seals (*Phoca hispida*). *Canadian Journal of Zoology* 68(12):2503-2512.
- Kendall, L. S., and L. A. Cornick. 2015. Behavior and distribution of Cook Inlet beluga whales, *Delphinapterus leucas*, before and during pile driving activity. *Marine Fisheries Review* 77(2):106-115.
- Kendall, L. S., K. Lomac-MacNair, G. Campbell, S. Wisdom, and N. Wolf. 2015. Cook Inlet 3D Seismic Surveys Marine Mammal Monitoring and Mitigation Report. Prepared for National Marine Fisheries Service Permits and Conservation Division Office of Protected Resources
- Kendall, L. S., A. Sirovic, and E. H. Roth. 2014. Effects of construction noise on the Cook Inlet beluga whale (*Delphinapterus leucas*) vocal behavior. *Canadian Acoustics* 41(3):3-13.
- Kenney, R. D., M. A. M. Hyman, R. E. Owen, G. P. Scott, and H. E. Winn. 1986. Estimation of prey densities required by western North Atlantic right whales. *Marine Mammal Science* 2(1):1-13.
- Ketten, D. R. 1997. Structure and function in whale ears. *Bioacoustics* 8:103-135.
- Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. *Ecology letters* 14(10):1052-1061.
- Kingsley, M. 2002. Cancer rates in St Lawrence belugas; comment on Martineau et al. 1999, cancer in beluga whales. *J Cetacean Res Manag. Special* (1):249-265.
- Klishin, V., V. Popov, and A. Y. Supin. 2000. Hearing capabilities of a beluga whale, *Delphinapterus leucas*. *Aquatic Mammals* 26(3):212-228.
- Koski, W. R., D. W. Funk, D. S. Ireland, C. Lyons, K. Christie, A. M. Macrander, and S. B. Blackwell. 2009. An update on feeding by bowhead whales near an offshore seismic survey in the central Beaufort Sea.
- Kovacs, K. M. 2007. Background document for development of a circumpolar ringed seal (*Phoca hispida*) monitoring plan. Marine Mammal Commission, L'Océanogràfic, Valencia, Spain.
- Krafft, B. A., C. Lydersen, K. M. Kovacs, I. Gjertz, and T. Haug. 2000. Diving behaviour of lactating bearded seals (*Erignathus barbatus*) in the Svalbard area. *Canadian Journal of Zoology* 78(8):1408-1418.
- Labansen, A. L., C. Lydersen, T. Haug, and K. M. Kovacs. 2007. Spring diet of ringed seals (*Phoca hispida*) from northwestern Spitsbergen, Norway. *ICES (International Council for the Exploration of the Seas) Journal of Marine Science* 64(6):1246-1256.
- Lafortuna, C. L., M. Jahoda, A. Azzellino, F. Saibene, and A. Colombini. 2003. Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (*Balaenoptera physalus*). *European Journal of Applied Physiology* 90(3-4):387-395.
- Laidre, K. L., M. P. Heide-Jorgensen, and T. G. Nielsen. 2007. Role of the bowhead whale as a

- predator in West Greenland. *Marine Ecology Progress Series* 346:285-297.
- Laidre, K. L., H. Stern, K. M. Kovacs, L. Lowry, S. E. Moore, E. V. Regehr, S. H. Ferguson, Ø. Wiig, P. Boveng, R. P. Angliss, E. W. Born, D. Litovka, L. Quakenbush, C. Lydersen, D. Vongraven, and F. Ugarte. 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. *Conservation Biology* 29(3):724-737.
- Lair, S., L. N. Measures, and D. Martineau. 2015. Pathologic Findings and Trends in Mortality in the Beluga (*Delphinapterus leucas*) Population of the St Lawrence Estuary, Quebec, Canada, From 1983 to 2012. *Veterinary Pathology* 53(1):22-36.
- Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. *Marine Mammal Science* 17(1):35-75.
- Lammers, M. O., M. Castellote, R. J. Small, S. Atkinson, J. Jenniges, A. Rosinski, J. N. Oswald, and C. Garner. 2013. Passive acoustic monitoring of Cook Inlet beluga whales (*Delphinapterus leucas*). *Journal of the Acoustical Society of America* 134(3):2497-2504.
- Laughlin, J. 2007. Underwater sound levels associated with driving steel and concrete piles near the Mukilteo Ferry Terminal. Washington State Department of Transportation Underwater Noise Technical Report. March 30, 2007.
- Learmonth, J. A., C. D. Macleod, M. B. Santos, G. J. Pierce, H. Q. P. Crick, and R. A. Robinson. 2006. Potential effects of climate change on marine mammals. *Oceanography and Marine Biology: An Annual Review* 44:431-464.
- Lefebvre, K. A., L. Quakenbush, E. Frame, K. B. Huntington, G. Sheffield, R. Stimmelmayer, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gill. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. *Harmful Algae* 55:13-24.
- Lentfer, J. W. 1972. Alaska polar bear research and management. Proc. of the 3rd Working Meeting of the Polar Bear Specialist Group; Survival Service Commission of IUCN. Publ. by N.Y. Zoo I. Soc. and Conserv. Found., Suppl. No. 35.
- LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc., and Greenridge Sciences Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.
- Ljungblad, D. K., S. E. Moore, J. T. Clarke, and J. C. Bennett. 1987. Distribution, Abundance, Behavior, and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-86. NOSC, San Diego, CA.
- Ljungblad, D. K., S. E. Moore, T. J. Clarke, ., and J. C. Bennett. 1986. Aerial surveys of endangered whales in the Northern Bering, Eastern Chukchi and Alaskan Beaufort Seas, 1985: with a seven year review, December 2011 Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact Statement 7-64 References 1979-85. USDO, MMS, Alaska OCS Region, Anchorage, AK.
- Ljungblad, D. K., B. Wursig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic* 41(3):183-194.
- Loeng, H., K. Brander, E. Carmack, S. Denisenko, K. Drinkwater, B. Hansen, K. Kovacs, P. Livingston, F. McLaughlin, and E. Sakshaug. 2005. Marine Ecosystems. Arctic Climate

- Impact Assessment (ACIA), Cambridge.
- Lomac-MacNair, K., C. Thissen, and M.A. Smultea. 2014. Draft NMFS 90-Day Report for Marine Mammal Monitoring and Mitigation during SAExploration's Colville River Delta 3D Seismic Survey, Beaufort Sea, Alaska, August to September 2014. Submitted to SAE, Prepared by Smultea Environmental Sciences, P.O. Box 256, Preston, WA 98050. December 2, 2014., Preston, WA.
- Lomac-MacNair, K., L. S. Kendall, and S. Wisdom. 2013. Marine mammal monitoring and mitigation 90-day report, May 6-September 30, 2012, Alaska Apache Corporation 3D seismic program, Cook Inlet, Alaska. SAExploration and Fairweather, Anchorage, AK.
- Lomac-MacNair, K., M. A. Smultea, M. P. Cotter, C. Thissen, and L. Parker. 2016. Socio-sexual and Probable Mating Behavior of Cook Inlet Beluga Whales, *Delphinapterus leucas*, Observed From an Aircraft. *Marine Fisheries Review* 77(2):32-39.
- London, J. M., J. M. Ver Hoef, S. J. Jeffries, M. M. Lance, and P. L. Boveng. 2012. Haul-out behavior of harbor seals (*Phoca vitulina*) in Hood Canal, Washington. *PLoS One* 7(6):e38180.
- Lowry, L., and G. Sheffield. 2002. Stomach contents of bowhead whales harvested in the Alaskan Beaufort Sea. Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information. *OCS Study MMS 12:61-44*.
- Lowry, L. F. 1993. Foods and feeding ecology. Pages 201-238 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*. Allen Press, Inc., Lawrence, KS.
- Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Variability in the diet of ringed seals, *Phoca hispida*, in Alaska. *Canadian Journal of Fisheries and Aquatic Sciences* 37(12):2254-2261.
- Lowry, L. F., G. Sheffield, and J. C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea, based on stomach contents analyses. *Journal of Cetacean Research Management* 6:215-223.
- Luksenburg, J. A., and E. C. M. Parsons. 2009. The effects of aircraft on cetaceans: implications for aerial whalewatching.
- Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T. F. Stocker. 2008. High-resolution carbon dioxide concentration record 650,000–800,000 years before present. *Nature* 453(7193):379-382.
- Lydersen, C. 1991. Monitoring ringed seal (*Phoca hispida*) activity by means of acoustic telemetry. *Canadian Journal of Zoology* 69(5):1178-1182.
- Lydersen, C. 1998. Status and biology of ringed seals (*Phoca hispida*) in Svalbard. Pages 46-62 17 in M. P. Heide-Jorgensen, and C. Lydersen, editors. *Ringed Seals in the North Atlantic*. NAMMCO Scientific Publications.
- Lydersen, C., and M. O. Hammill. 1993. Diving in ringed seal (*Phoca hispida*) pups during the nursing period. *Canadian Journal of Zoology* 71(5):991-996.
- Lydersen, C., M. O. Hammill, and K. M. Kovacs. 1994. Diving activity in nursing bearded seal (*Erignathus barbatus*) pups. *Canadian Journal of Zoology* 72(1):96-103.
- Lydersen, C., P. M. Jensen, and E. Lydersen. 1987. Studies of the ringed seal (*Phoca hispida*) population in the Van Mijen fiord, Svalbard, in the breeding period 1986.
- Lydersen, C., and K. M. Kovacs. 1999. Behaviour and energetics of ice-breeding, North Atlantic phocid seals during the lactation period. *Marine Ecology Progress Series* 187:265-281.
- Lydersen, C., K. M. Kovacs, M. O. Hammill, and I. Gjertz. 1996. Energy intake and utilisation

- by nursing bearded seal (*Erignathus barbatus*) pups from Salbard, Norway. *Journal of Comparative Physiology B Biochemical Systemic and Environmental Physiology* 166(7):405-411.
- Lydersen, C., and M. S. Ryg. 1990. An evaluation of Tempelfjorden and Sassenfjorden as breeding habitat for ringed seals *Phoca hispida*. Pages 33-40 in T. Severinsen, and R. Hansson, editors. *Environmental Atlas Gipsdalen, Svalbard, volume III: Reports on the Fauna of Gipsdalen*. Norsk Polarinstitutt Rapportserie.
- Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. *Polar Biology* 9(8):489-490.
- MacDonald, R. W. 2005. Climate change, risks and contaminants: A perspective from studying the Arctic. *Human and Ecological Risk Assessment* 11:1099-1104.
- MacIntyre, K. Q., K. M. Stafford, C. L. Berchok, and P. L. Boveng. 2013. Year-round acoustic detection of bearded seals (*Erignathus barbatus*) in the Beaufort Sea relative to changing environmental conditions, 2008–2010. *Polar Biology* 36(1161-1173).
- MacIntyre, K. Q., K. M. Stafford, P. B. Conn, K. L. Laidre, and P. L. Boveng. 2015. The relationship between sea ice concentration and the spatio-temporal distribution of vocalizing bearded seals (*Erignathus barbatus*) in the Bering, Chukchi, and Beaufort Seas from 2008 to 2011. *Progress in Oceanography* 136:241-249.
- MacLeod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. *Endangered Species Research* 7(2):125-136.
- Malme, C. I., B. Wursig, J. E. Bird, and P. Tyack. 1988. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling, Anchorage, AK.
- Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region.
- Manning, T. H. 1974. Variation in the skull of the bearded seal, *Erignathus barbatus* (Erxleben). *Biological Papers of the University of Alaska* 16:1-21.
- Marquette, W. M., and J. R. Bockstoce. 1980. Historical Shore-Based Catch of Bowhead Whales in the Bering, Chukchi, and Beaufort Seas. *Marine Fisheries Review*:96.
- Marshall, C. D., H. Amin, K. M. Kovacs, and C. Lydersen. 2006. Microstructure and innervation of the mystacial vibrissal follicle-sinus complex in bearded seals, *Erignathus barbatus* (Pinnipedia: Phocidae). *Anatomical Record Part A-Discoveries in Molecular Cellular and Evolutionary Biology* 288A(1):13-25.
- Marty, G. D., D. E. Hinton, J. W. Short, R. A. Heintz, S. D. Rice, D. M. Dambach, N. H. Willits, and J. J. Stegeman. 1997. Ascites, premature emergence, increased gonadal cell apoptosis, and cytochrome P4501A induction in pink salmon larvae continuously exposed to oil-contaminated gravel during development. *Canadian Journal of Zoology* 75(6):989-1007.
- Maruska, K. P., and A. F. Mensinger. 2009. Acoustic characteristics and variations in grunt vocalizations in the oyster toadfish *Opsanus tau*. *Environmental biology of fishes* 84(3):325-337.
- McCarthy, J. J. 2001. Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T.

- Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: Analysis of airgun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid: report on research conducted for The Australian Petroleum Production and Exploration Association.
- McCauley, R. D., J. Fewtrell, and A. N. Popper. 2003. High intensity anthropogenic sound damages fish ears. *The Journal of the Acoustical Society of America* 113(1):638-642.
- McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a sea-floor array in the Northeast Pacific. *Journal of the Acoustical Society of America* 98(2):712-721.
- McDonald, T. L., W.J. Richardson, C.R. Greene, and S. B. Blackwell. 2006. Evidence of Subtle Bowhead Whale Deflection near Northstar at High-Noise Times based on Acoustic Localization Data, 2001–2004. W.J. Richardson, ed. LGL Report TA4256A-9. King City, Ont., Canada: LGL, pp. 9–1 to 9–38.
- McGuire, T., M. Blees, and M. Bourdon. 2011. Photo-identification of beluga whales in upper Cook Inlet, Alaska. Final report of field activities and belugas resighted in 2009. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Fish and Wildlife Foundation, Chevron, and ConocoPhillips Alaska. Inc.
- McGuire, T., and A. Stephens. 2017. Photo-identification of Beluga Whales in Cook Inlet, Alaska: Summary and Synthesis of 2005-2015 Data. Final Report. LGL Alaska Research Associates, Inc. Prepared for: National Marine Fisheries Service Alaska Region, Protected Resources Division, Anchorage, AK.
- McGuire, T., A. Stephens, and L. Bisson. 2013. Photo-identification of Cook Inlet beluga whales in the waters of the Kenai Peninsula Borough, Alaska. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for Department of Defense, U.S. Air Force, JBER, and the Alaska Department of Fish and Game. , Final report of field activities and belugas identified 2011-2013.
- McGuire, T., A. Stephens, and L. Bisson. 2014. Photo-identification of Cook Inlet beluga whales in the waters of the Kenai Peninsula Borough, Alaska. Final report of field activities and belugas identified 2011–2013. Kenai Peninsula Borough.
- Melcon, M. L., A. J. Cummins, S. M. Kerosky, L. K. Roche, S. M. Wiggins, and J. A. Hildebrand. 2012. Blue whales respond to anthropogenic noise. *PLoS One* 7(2):e32681.
- Mellinger, D. K., K. M. Stafford, and C. G. Fox. 2004. Seasonal occurrence of sperm whale (*Physeter macrocephalus*) sounds in the Gulf of Alaska, 1999–2001. *Marine Mammal Science* 20(1):48-62.
- Melnikov, V., and I. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. *Marine Mammal Science* 21(3):550-556.
- Miller, G., R. Elliott, T. Thomas, V. Moulton, and W. Koski. 2002. Distribution and numbers of bowhead whales in the eastern Alaskan Beaufort Sea during late summer and autumn, 1979-2000. Richardson, WJ and DH Thomson (eds):2002-012.
- Miller, G., V. Moulton, R. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Offshore oil and gas environmental effects monitoring/Approaches and technologies. Battelle Press, Columbus, OH:511-542.
- Miller, P. J., N. Biassoni, A. Samuels, and P. L. Tyack. 2000. Whale songs lengthen in response to sonar. *Nature* 405(6789):903.
- Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman. 2009. Distribution

- and movements of fin whales in the North Pacific Ocean. *Mammal Review* 39(3):193-227.
- MMS. 2002. Liberty development and production plan : final environmental impact statement / Minerals Management Service, Alaska OCS Region. . U.S. Dept. of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK.
- Mocklin, J., J. George, M. Ferguson, L. Vate Brattström, V. Beaver, B. Rone, C. Christman, A. Brower, B. Shea, and C. Accardo. 2012. Aerial photography of bowhead whales near Barrow, Alaska, during the 2011 spring migration. *IWC* 64.
- Mocklin, J. A. 2009. Evidence of bowhead whale feeding behavior from aerial photography. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Service, Seattle, WA.
- Møhl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. *The Journal of the Acoustical Society of America* 114(2):1143-1154.
- Monnett, C., and S. D. Treacy. 2005. Aerial surveys of endangered whales in the Beaufort Sea, fall 2002-2004. Pages 153 *in* Minerals Management Service, editor, Anchorage, Alaska.
- Mooney, T. A., P. E. Nachtigall, M. Castellote, K. A. Taylor, A. F. Pacini, and J.-A. Esteban. 2008. Hearing pathways and directional sensitivity of the beluga whale, *Delphinapterus leucas*. *Journal of Experimental Marine Biology and Ecology* 362(2):108-116.
- Moore, S. E., J. C. George, G. Sheffield, J. Bacon, and C. J. Ashjian. 2010. Bowhead Whale Distribution and Feeding near Barrow, Alaska, in Late Summer 2005-06. *Arctic* 63(2):195-205.
- Moore, S. E., and H. P. Huntington. 2008. Arctic marine mammals and climate change: impacts and resilience. *Ecological applications* 18(sp2).
- Moore, S. E., and K. L. Laidre. 2006. Trends in sea ice cover within habitats used by bowhead whales in the Western Arctic. *Ecological applications* 16(3):932-944.
- Moore, S. E., and R. R. Reeves. 1993. Distribution and movement Pages 313-386 *in* J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*, volume Special Publication Number 2. Society of Marine Mammalogy.
- Moore, S. E., K. E. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. *Marine Fisheries Review* 62(3):60-80.
- Moore, S. E., K. M. Stafford, M. E. Dahlheim, C. G. Fox, H. W. Braham, J. J. Polovina, and D. E. Bain. 1998. Seasonal variation in reception of fin whale calls at five geographic areas in the North Pacific. *Marine Mammal Science* 14(3):617-627.
- Moore, S. E., K. M. Stafford, D. K. Mellinger, and J. A. Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. *Bioscience* 56(1):49-55.
- Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS) joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. AFSC Quarterly Report Feature (July-August-September 2013) 6 p. (.pdf, 5.86 MB).
- Morris, J. F. T., M. Trudel, M. E. Thiess, R. M. Sweeting, J. Fisher, S. A. Hinton, E. A. Fergusson, J. A. Orsi, E. V. Farley, and D. W. Welch. 2007. Stock-specific migrations of juvenile coho salmon derived from coded-wire tag recoveries on the continental shelf of western North America. *Ecology of Juvenile Salmon in the Northeast Pacific Ocean: Regional Comparisons* 57:81-104.
- Mossner, S., and K. Ballschmiter. 1997. Marine mammals as global pollution indicators for organochlorines. *Chemosphere* 34(5-7):1285-1296.

- Moulton, V. D., R. E. Elliot, W. J. Richardson, and T. L. McDonald. 2002a. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 2001 (and 1997-2001 combined). In: Richardson, W.J. and M.T. Williams (eds.) 2002. Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2001.
- Moulton, V. D., R. E. Elliott, T. L. McDonald, and W. J. Richardson. 2001. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 2000 (and 1997-2000 combined). W. J. Richardson, and M. T. Williams, editors. Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2000. Report from LGL Alaska Resources Associates and Greeneridge Sciences Inc., Anchorage, AK.
- Moulton, V. D., R. E. Elliott, and M. T. Williams. 2003. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 2002, Anchorage, AK.
- Moulton, V. D., T. L. McDonald, W. J. Richardson, R. E. Elliott, and M. T. Williams. 2000. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 1999 (and 1997-99 combined). W. J. Richardson, and M. T. Williams, editors. Monitoring of ringed seals during construction of ice roads for BP's Northstar oil development, Alaskan Beaufort Sea, 1999. Final Report from LGL Alaska Res. Assoc. Inc, Anchorage, AK.
- Moulton, V. D., W. J. Richardson, T. L. McDonald, R. E. Elliott, and M. T. Williams. 2002b. Factors influencing local abundance and haulout behavior of ringed seals (*Phoca hispida*) on landfast ice of the Alaskan Beaufort Sea. Canadian Journal of Zoology-Revue Canadienne De Zoologie 90:1900-1917.
- Murray, N. K., and F. H. Fay. 1979. The white whales or belukhas, *Delphinapterus leucas*, of Cook Inlet, Alaska. International Whaling Commission Scientific Committee.
- Muto, M. M., V. Helker, R. P. Angliss, P. Boveng, J. M. Breiwick, M. Cameron, P. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. Fritz, R. C. Hobbs, Y. V. Ivaschenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. Shelden, K. L. Sweeney, R. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2019. Alaska marine mammal stock assessments, 2018. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-393. Pages 390 *in*.
- Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. NOAA Tech. Memo. NMFS-AFSC-355, Alaska Fisheries Science Center 7600 Sand Point Way N.E. Seattle, WA 98115.
- Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2018. Alaska marine mammal stock assessments, 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-378, 382 p.
- Myers, K. W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dahlberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. University of Washington, Fisheries Research Institute, FRI-UW-9614 (NPAFC

- Document 192), Seattle, Washington.
- Nakken, O. 1992. Scientific basis for management of fish resources with regard to seismic exploration, Fisheries and Offshore Petroleum Exploitation 2nd International Conference, Bergen Norway, April 6-8, 1992.
- NASA. 2020. State of the Climate: How the World Warmed in 2019. Posted January 20, 2020. <https://www.carbonbrief.org/state-of-the-climate-how-the-world-warmed-in-2019>.
- National Marine Fisheries Service. 2016. 2016 5-year review: summary & evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River Basin steelhead. National Marine Fisheries Service, West Coast Region, Portland, Oregon.
- Neff, J. M. 1990. Composition and Fate of Petroleum and Spill-Treating Agents in the Marine Environment. Pages 1-33 in J. R. Geraci, and D. J. St. Aubin, editors. Sea Mammals and Oil: Confronting the Risks. Academic Press, New York, NY.
- Neff, J. M. 2010. Fate and effects of water based drilling muds and cuttings in cold water environments. A Scientific Review prepared for Shell Exploration and Production Company, Houston, Texas.
- Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. Straley. 2012. Summary of Reported Whale-Vessel Collisions in Alaskan Waters. Journal of Marine Biology 2012(Article ID 106282):18.
- Nelson, M. A., L. T. Quakenbush, B. A. Mahoney, B. D. Taras, and M. J. Wooller. 2018. Fifty years of Cook Inlet beluga whale feeding ecology from isotopes in bone and teeth. Endangered Species Research 36:77-87.
- Nelson, R. K. 1981. Harvest of the sea: Coastal subsistence in modern Wainwright. North Slope Borough, Coastal Management Program, North Slope Borough, Alaska.
- Nelson, R. R., J. J. Burns, and K. J. Frost. 1984. The bearded seal (*Erignathus barbatus*). Pages 1-6 in J. J. Burns, editor. Marine Mammal Species Accounts, Wildlife Technical Bulletin, volume 7. Alaska Department of Fish and Game, Juneau, AK.
- Nemeth, M. J., C. C. Kaplan, A. M. Prevel-Ramos, G. D. Wade, D. M. Savarese, and C. D. Lyons. 2007. Baseline studies of marine fish and mammals in Upper Cook Inlet, April through October 2006. Final report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK for DRven Corporation, Anchorage, AK.
- Nemoto, T. 1970. Feeding pattern of baleen whales in the ocean. Pages 241-252 in J. H. Steele, editor. Marine Food Chains. University of California Press, Berkeley, CA.
- NMFS. 1991. Final recovery plan for the humpback whale (*Megaptera novaeangliae*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2006. Endangered Species Act section 7 consultation biological opinion on the United States Navy's 2006 Rim-of-the-Pacific Joint Training Exercises. N. M. F. S. Office of Protected Resources, editor. National Oceanic and Atmospheric Administration, Department of Commerce, , Silver Spring, MD.
- NMFS. 2008a. Final Conservation Plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). N. Department of Commerce, editor, Anchorage, AK.
- NMFS. 2008b. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Revision. U. S. DOC/NOAA/NMFS, editor, Silver Spring, Maryland.
- NMFS. 2010a. Endangered Species Act Section 7 Consultation Biological Opinion for the authorization of groundfish fisheries under the Fishery Management Plan for Groundfish for the Bering Sea and Aleutian Islands Management Area and the Fishery Management

- Plan for groundfish of the Gulf of Alaska. A. R. National Marine Fisheries Service, editor, Juneau, AK.
- NMFS. 2010b. Endangered Species Act, Section 7 consultation on the U.S. Environmental Protection Agency's proposed approval of the State of Alaska's mixing zone regulation section of the State of Alaska Water Quality Standards.75.
- NMFS. 2010c. Final recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD.
- NMFS. 2010d. Recovery plan for the fin whale (*Balaenoptera physalus*), National Marine Fisheries Service, Silver Spring, MD.
- NMFS. 2013a. Effects of oil and gas activities in the Arctic Ocean: supplemental draft Environmental Impact Statement. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.
- NMFS. 2013b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion on Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska. A. R. O. National Marine Fisheries Service, editor, Juneau, Alaska.
- NMFS. 2013c. Final recovery plan for the North Pacific Right Whale (*Eubalaena japonica*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.
- NMFS. 2014a. Endangered Species Act section 7 consultation biological opinion for the issuance of Incidental Harassment Authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to SAExploration, Inc. (SAE) for marine 3D ocean bottom node seismic activities in the U.S. Beaufort Sea, Colville River Delta, Alaska, during the 2014 open water season. N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Juneau, Alaska., editor.
- NMFS. 2014b. Endangered Species Act section 7(a)(2) biological opinion on the issuance of an incidental harassment authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for shallow geohazard survey in the U.S. Beaufort Sea, Foggy Island Bay, Alaska, during the 2014 open water season. N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Juneau, Alaska., editor.
- NMFS. 2014c. ESA Sect 7 Biological Opinion on the Issuance of Incidental Harassment Authorization under Section 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for Marine 3D Ocean Bottom Sensor Seismic Activities in the U.S. Beaufort Sea, Prudhoe Bay, Alaska, during the 2014 Open Water Season. National Marine Fisheries Service, Alaska Regional Office, Juneau, AK.
- NMFS. 2015a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Section 7(a)(4) Conference Report on Lease Sale 193 Oil and Gas Exploration Activities in the U.S. Chukchi Sea, Alaska. Issued June 4, 2016. Pages 342 *in*.
- NMFS. 2015b. Endangered Species Act section 7(a)(2) consultation biological opinion and section 7(a)(4) conference opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell Gulf of Mexico and Shell Offshore Inc. (Shell) for aviation operations associated with ice condition monitoring over the Beaufort and Chukchi Seas from May 2015 through April 2016. N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, editor, Juneau, Alaska.
- NMFS. 2016a. Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact

- Statement. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protective Resources, Silver Spring, MD.
- NMFS. 2016b. Recovery Plan for the Cook Inlet Beluga Whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK.
- NMFS. 2016c. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.
- NMFS. 2016d. U.S. National Bycatch Report First Edition Update 2. U.S. Dep. Commer.
- NMFS. 2017a. Biological Opinion for Furie's Offshore Oil and Gas Exploration Drilling in the Kitchen lights Unit of Cook Inlet, Alaska. NOAA National Marine Fisheries Service.
- NMFS. 2017b. Endangered Species Act Section 7 Letter of Concurrence for barge dock repair, Port MacKenzie, Matanuska-Susitna Borough, POA-1979-412, Upper Cook Inlet. May 15, 2017. Dept. of Comm., NMFS, Protected Resources Division, Alaska Region, Anchorage, AK.
- NMFS. 2018a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion for Liberty Oil and Gas Development and Production Plan Activities, Beaufort Sea, Alaska, NMFS Consultation Number: AKR-2018-9747, National Marine Fisheries Service Alaska Regional Office. Juneau, Alaska.
- NMFS. 2018b. Endangered Species Act Section 7(a)(2) Biological Opinion on the Issuance of a U.S. Army Corps of Engineers Permit and Incidental Harassment Authorization for Harvest Alaska LLC Cook Inlet Pipeline Cross-Inlet Extension Project, NMFS Consultation Number AKR-2018-9719, National Marine Fisheries Service Alaska Regional Office. Anchorage, AK.
- NMFS. 2018c. Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.
- NMFS. 2019. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion for Alaska Fisheries Science Center Surveys in the Gulf of Alaska, Bering Sea/Aleutian Islands, and Chukchi Sea/Beaufort Sea Research Areas, 2019-2022 and the International Pacific Halibut Commission Surveys in the GOA and BS, 2019-2022. A. R. O. National Marine Fisheries Service, editor, Juneau, Alaska.
- NOAA. 2019. Alaska Fisheries Science Center presentation at the Alaska Eskimo Whaling Commission meeting, October 29, 2019.
- NOAA National Centers for Environmental Information. 2020. Climate at a Glance: Global Mapping, published May 2020, retrieved on June 1, 2020 from <https://www.ncdc.noaa.gov/cag/>.
- Noad, M. J., and D. H. Cato. 2007. Swimming speeds of singing and non-singing humpback whales during migration. *Marine Mammal Science* 23(3):481-495.
- Noongwook, G., H. P. Huntington, and J. George. 2007a. Traditional knowledge of the bowhead whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. *Arctic* 60(1):47-54.
- Noongwook, G., H. P. Huntington, J. C. George, Native Village Savoonga, and Native Village Gambell. 2007b. Traditional knowledge of the bowhead whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. *Arctic* 60(1):47-54.

- Nordon. 2014. Marine Invasive Species in the Arctic. Nordic Council of Ministers. TemaNord 2014:547.
- Noren, D., A. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by southern resident killer whales. *Endangered Species Research* 8(3):179-192.
- Norman, S. A. 2011. Nonlethal anthropogenic and environmental stressors in Cook Inlet beluga whales (*Delphinapterus leucas*): Report prepared for NOAA Fisheries, National Marine Fisheries Service, Anchorage, Alaska. NMFS contract no. HA133F-10-SE-3639. 113p.
- Norman, S. A., R. C. Hobbs, C. E. Goertz, K. A. Burek-Huntington, K. E. Shelden, W. A. Smith, and L. A. Beckett. 2015. Potential natural and anthropogenic impediments to the conservation and recovery of Cook Inlet beluga whales, *Delphinapterus leucas*. *Mar. Fish. Rev* 77(2):89-105.
- Norse, E. A., and L. B. Crowder. 2005. The science of maintaining the sea's biodiversity. Island Press, Washington, D.C.
- Northwest Fisheries Science Center. 2017. Module for the ocean environment. June 2014. Prepared for NOAA Fisheries, Northwest Regional Office.
- Nøttestad, L., A. Fernö, S. Mackinson, T. Pitcher, and O. A. Misund. 2002. How whales influence herring school dynamics in a cold-front area of the Norwegian Sea. *ICES Journal of Marine Science* 59(2):393-400.
- Nowacek, D. P., C. W. Clark, D. Mann, P. J. O. Miller, H. C. Rosenbaum, J. S. Golden, M. Jasný, J. Kraska, and B. L. Southall. 2015. Marine seismic surveys and ocean noise: time for coordinated and prudent planning. *Frontiers in Ecology and the Environment* 13(7):378-386.
- Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. *Mammal Review* 37(2):81-115.
- NRC. 2003. Ocean Noise and Marine Mammals. National Academy Press, Washington, D.C.
- NSIDC. 2019. Monthly Archives. 2019. <http://nsidc.org/arcticseaicenews/2019/10/>.
- Nuka Research and Planning Group. 2015a. Aleutian Islands risk assessment: recommending an optimal response system for the Aleutian Islands. Summary Report prepared for the National Fish and Wildlife Foundation, USCG, and Alaska Department of Environmental Conservation.
- Nuka Research and Planning Group. 2016. Bering Sea Vessel Traffic Analysis.
- Nuka Research and Planning Group, L. 2012. Southeast Alaska Vessel Traffic Study, July 23, 2012, Revision 1.
- Nuka Research and Planning Group, L. 2015b. Aleutian Islands risk assessment: recommending an optimal response system for the Aleutian Islands. Summary Report prepared for the National Fish and Wildlife Foundation, USCG, and Alaska Department of Environmental Conservation.
- OASIS Environmental Inc. 2006. Dutch Harbor Water Quality and Impairment Analysis: Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor, Unalaska, Alaska. Final Report for the Alaska Department of Environmental Conservation, June 2006.
- Ognev, S. I. 1935. Mammals of U.S.S.R. and adjacent countries. Volume 3. Carnivora, volume 3. Glavpushnina NKVT, Moscow, Russia.
- Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Reports of the International Whaling Commission 24:114-126.
- Olsen, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo

- survey vessel, ICES CM 1979/B:18:1-21.
- Olsen, K., J. Angell, F. Pettersen, and A. Løvik. 1983. Observed fish reactions to a surveying vessel with special reference to herring, cod, capelin and polar cod. FAO Fish. Rep. 300.
- Omura, H. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangst-Tidende 7:395-405.
- Ona, E., and O. R. Godø. 1990. Fish reaction to trawling noise: the significance for trawl sampling. Rapports et Proces-verbaux des Réunions. Conseil International pour l'Exploration de la Mer 189:159-166.
- Ona, E., and R. Toresen. 1988. Avoidance reactions of herring to a survey vessel, studied by scanning sonar. International Council for the Exploration of the Sea, Fish Capture Committee. CM.1988/H:46,1-8.
- Oreskes, N. 2004. The scientific consensus on climate change. Science 306(5702):1686-1686.
- Orr, J. C., V. J. Fabry, O. Aumont, L. Bopp, S. C. Doney, R. A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R. M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R. G. Najjar, G.-K. Plattner, K. B. Rodgers, C. L. Sabine, J. L. Sarmiento, R. Schlitzer, R. D. Slater, I. J. Totterdell, M.-F. Weirig, Y. Yamanaka, and A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437:681-686.
- Outridge, P., R. Macdonald, F. Wang, G. Stern, and A. Dastoor. 2008. A mass balance inventory of mercury in the Arctic Ocean. Environmental Chemistry 5(2):89-111.
- Overholtz, W., and J. Nicolas. 1979. Apparent feeding by the fin whale, *Balaenoptera physalus*, and the humpback whale, *Megaptera novaengliae*, on the American sand lance, *Ammodytes americanus*, in the Northwest Atlantic Fisheries Bulletin 71(1):285-287.
- Overland, J. E., E. Hanna, I. Hanssen-Bauer, S.-J. Kim, J. E. Walsh, M. Wang, U. S. Bhatt, and R. L. Thoman. 2017. Arctic Report Card 2017, <http://www.arctic.noaa.gov/Report-Card>, U. S. Dept. Commerce, NOAA Arctic Program.
- Ovitz, K. 2019. Exploring Cook Inlet beluga whale (*Delphinapterus leucas*) habitat use in Alaska's Kenai River. Prepared for National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Protected Resources Division, Anchorage, AK.
- Owl Ridge, N. 2014. Cosmopolitan State 2013 Drilling Program Marine Mammal Monitoring and Mitigation 90-day Report. Prepared for BlueCrest Alaska Operating LLC.
- Panigada, S., M. Zanardelli, S. Canese, and M. Jahoda. 1999. Deep diving performances of Mediterranean fin whales. Pages 144 *in*.
- Panigada, S., M. Zanardelli, M. MacKenzie, C. Donovan, F. Mélin, and P. S. Hammond. 2008. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. Remote Sensing of Environment 112(8):3400-3412.
- Parks, S. E. 2003. Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science 19(3):563-580.
- Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.
- Parks, S. E., D. R. Ketten, J. T. O'Malley, and J. Arruda. 2007. Anatomical predictions of hearing in the North Atlantic right whale. The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology 290(6):734-744.
- Parry, M. L. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability: Working

- Group II Contribution to the Fourth Assessment Report of the IPCC Intergovernmental Panel on Climate Change, volume 4. Cambridge University Press.
- Patenaude, N. J., W. J. Richardson, M. A. Smultea, W. R. Koski, G. W. Miller, B. Wursig, and C. R. Greene. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* 18(2):309-335.
- Patenaude, N. J., M. A. Smultea, W. R. Koski, W. J. Richardson, and C. R. Greene. 1997. Aircraft Sound and Aircraft Disturbance to Bowhead and Beluga Whales during the Spring Migration in the Alaskan Beaufort Sea. Pages 37 *in*. LGL Ltd. Environmental Research Associates, King City, Ont., Canada.
- Patterson, B., and G. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. Proceedings of a Symposium held at the Lerner Marine Laboratory Bimini, Bahamas. Pages 125-145 *in* W. N. Tavolga, editor. *Marine Bioacoustics*, Pergamon Press Oxford.
- Payne, K., and R. Payne. 1985. Large scale changes over 19 years in songs of humpback whales in Bermuda. *Zeitschrift für Tierpsychologie* 68(2):89-114.
- Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences* 188(1):110-141.
- Peterson, W., N. Bond, and M. Robert. 2016. The blob (part three): Going, going, gone? PICES Press 24(1):46.
- Philo, L. M., E. Shotts, and J. C. George. 1993. Morbidity and mortality. The bowhead whale. *Soc. Mar. Mammal., Spec. Publ* (2):275-312.
- Pirotta, E., N. D. Merchant, P. M. Thompson, T. R. Barton, and D. Lusseau. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. *Biological Conservation* 181:82-89.
- POA. 2003. Environmental baseline survey for the Port of Anchorage road and rail extension right of way. U.S. Army Defense Fuels Property.
- POA. 2019. June 2019 Marine Mammal Observation Report. Submitted to NMFS July 15, 2019, Anchorage, AK.
- Popper, A., T. Carlson, B. Casper, and M. Halvorsen. 2014. Does man-made sound harm fishes. *Journal of Ocean Technology* 9(1):11-20.
- Popper, A. N., and M. C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* 75(3):455-489.
- Powilleit, M., G. Graf, J. Kleine, R. Riethmueller, K. Stockmann, M. A. Wetzel, and J. H. E. Koop. 2009. Experiments on the survival of six brackish macro-invertebrates from the Baltic Sea after dredged spoil coverage and its implications for the field. *Journal of Marine Systems* 75(441-451).
- Quakenbush, L. 2018. Tagged Bowhead Whale Data in respects to Liberty Project. B. Easley-Appleyard, editor.
- Quakenbush, L., J. Citta, and J. Crawford. 2011. Biology of the ringed seal (*Phoca hispida*) in Alaska, 1960-2010. Final Report to: National Marine Fisheries Service.
- Quakenbush, L., J. Citta, J. C. George, R. J. Small, M. P. Heide-Jorgensen, L. Harwood, and H. Brower. 2010. Western Arctic bowhead whale movements and habitat use throughout their migratory range: 2006–2009 satellite telemetry results. Pages 108 *in* Alaska Marine Science Symposium, Anchorage, Alaska.
- Quakenbush, L., R. Small, and J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. US Dept. of the Interior, Bureau of Ocean Energy

- Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 1110:60.
- Quakenbush, L., R. S. Suydam, A. L. Bryan, L. F. Lowry, K. J. Frost, and B. A. Mahoney. 2015. Diet of beluga whales (*Delphinapterus leucas*) in Alaska from stomach contents, March–November. *Mar Fish Rev* 77:70-84.
- Quakenbush, L. T., J. A. Crawford, M. A. Nelson, and J. R. Olnes. 2019. Pinniped movements and foraging: village-based satellite tracking and collection of traditional ecological knowledge regarding ringed and bearded seals. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK.
- Raum-Suryan, K. L., L. A. Jemison, and K. W. Pitcher. 2009. Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions. *Marine Pollution Bulletin* 58(10):1487-1495.
- Reese, C. S., J. A. Calvin, J. C. George, and R. J. Tarpley. 2001. Estimation of Fetal Growth and Gestation in Bowhead Whales. *Journal of the American Statistical Association* 96(455):915-938.
- Reeves, R. R. 1998. Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. Pages 9-45 in M. P. Heide-Jørgensen, and C. Lydersen, editors. *Ringed Seals in the North Atlantic*, volume 1. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.
- Reine, K., D. Clarke, and C. Dickerson. 2012. Characterization of underwater sounds produced by a backhoe dredge excavating rock and gravel. DTIC Document.
- Reisdorph, S. C., and J. T. Mathis. 2014. The dynamic controls on carbonate mineral saturation states and ocean acidification in a glacially dominated estuary. *Estuarine, Coastal and Shelf Science* 144:8-18.
- Reiser, C. M., D. W. Funk, R. Rodrigues, and D. Hannay. 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report.
- Rexford, B. 1997. A native whaler's view.
- Rhoads, D. C., P. L. McCall, and J. Y. Yingst. 1978. Disturbance and Production on the Estuarine Seafloor: Dredge-spoil disposal in estuaries such as Long Island Sound can be managed in ways that enhance productivity rather than diminish it. *American Scientist* 66:577-586.
- Rice, D. W. 1989. Sperm whale *Physeter macrocephalus* Linnaeus, 1758. Pages 177-233 in S. Ridgway, and R. Harrison, editors. *Handbook of marine mammals*, volume 4. Academic Press, New York, New York.
- Rice, D. W. 1998. *Marine mammals of the world: Systematics and distribution*. The Society for Marine Mammology, Lawrence, Kansas.
- Richardson, W. J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep. TA2150-3. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc.
- Richardson, W. J. 1999. Marine mammal and acoustical monitoring of Western Geophysical's openwater seismic program in the Alaskan Beaufort Sea, 1998. . Report from LGL Ltd., King City, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for western Geophysical, Houston, TX and National Marine fisheries Service, Anchorage, AK, TA2230-3.

- Richardson, W. J. 2008. Monitoring of Industrial Sounds, Seals, and Bowhead Whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2004.
- Richardson, W. J., M. A. Fraker, B. Wursig, and R. S. Wells. 1985. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: Reactions to industrial activities. *Biological Conservation* 32(3):195-230.
- Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995. *Marine Mammals and Noise*. Academic Press, Inc., San Diego, CA.
- Richardson, W. J., and C. I. Malme. 1993. Man-made noise and behavioral responses. Pages 631-700 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*. Society for Marine Mammology, .
- Richardson, W. J., and M. T. Williams. 2000. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999, Anchorage, Alaska.
- Richardson, W. J., and M. T. Williams. 2003. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999–2002, Anchorage, Alaska.
- Richardson, W. J., B. Wursig, and C. R. Greene. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America* 79(4):1117-1128.
- Richardson, W. J., B. Wursig, and C. R. Greene Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. *Marine Environmental Research* 29(2):135-160.
- Ridgway, S. H., D. A. Carder, T. Kamolnick, R. R. Smith, C. E. Schlundt, and W. R. Elsberry. 2001. Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*Delphinapterus leucas*) (Odontoceti, Cetacea). *Journal of Experimental Biology* 204(22):3829-3841.
- Riedman, M. 1990. *The pinnipeds: Seals, sea lions, and walruses*. University of California Press, Berkeley, CA. 439pgs. ISBN 0-520-06498-4.
- Rigzone. 2012. Apache Deploying Wireless Seismic Technology in Alaska's Cook Inlet.
- Rodkin, I. a. 2009. Acoustic Monitoring and In-situ Exposures of Juvenile Coho Salmon to Pile Driving Noise at the Port of Anchorage Marine Terminal Redevelopment Project Knik Arm, Anchorage, Alaska. Prepared for USDOT and POA.
- Rolland, R. M., K. E. Hunt, S. D. Kraus, and S. K. Wasser. 2005. Assessing reproductive status of right whales (*Eubalaena glacialis*) using fecal hormone metabolites. *Gen Comp Endocrinol* 142(3):308-17.
- Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. K. Wasser, and S. D. Kraus. 2012. Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences* 279(1737):2363-2368.
- Romano, T., M. Keogh, C. Kelly, P. Feng, L. Berk, C. Schlundt, D. Carder, and J. Finneran. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences* 61(7):1124-1134.
- Romero, L. M., C. J. Meister, N. E. Cyr, G. Kenagy, and J. C. Wingfield. 2008. Seasonal glucocorticoid responses to capture in wild free-living mammals. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* 294(2):R614-R622.
- Rone, B. K., A. N. Zerbini, A. B. Douglas, D. W. Weller, and P. J. Clapham. 2017. Abundance

- and distribution of cetaceans in the Gulf of Alaska. *Marine Biology* 164(23).
- Ruggerone, G., R. Goodman, and Miner. 2014. Behavioral Response and Survival of Juvenile Coho Salmon Exposed to Pile Driving Sounds.
- Rugh, D. J., K. E. Shelden, and B. A. Mahoney. 2000. Distribution of Belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska, During June/July 1993–2000. *Marine Fisheries Review* 62(3):6-21.
- Rugh, D. J., K. E. Shelden, C. L. Sims, B. A. Mahoney, B. K. Smith, L. K. Litzky, and R. C. Hobbs. 2005. Aerial surveys of beluga in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.
- Rugh, D. J., K. E. W. Shelden, and R. C. Hobbs. 2010. Range contraction in a beluga whale population. *Endangered Species Research* 12(1):69-75.
- Sabine, C. L., R. A. Feely, N. Gruber, R. M. Key, K. Lee, J. L. Bullister, R. Wanninkhof, C. S. Wong, D. W. R. Wallace, B. Tilbrook, F. J. Millero, T. H. Peng, A. Kozyr, T. Ono, and A. F. Rios. 2004. The oceanic sink for anthropogenic CO₂. *Science* 305:367-371.
- Saupe, S. M., T. M. Willette, D. L. Wetzell, and J. E. Reynolds. 2014. Assessment of the Prey Availability and Oil-related Contaminants in Winter Habitat of Cook Inlet Beluga Whales. Final Report of Field Surveys and Laboratory Analyses (2011-2013). Report prepared by Cook Inlet Regional Citizens Advisory Council (RCAC) for the Kenai Peninsula Borough. 53 pp.
- Savage, K. 2019. Health evaluation of ringed seals documented in the Southern Bering Region, Winter 2017-Spring 2018. Report prepared for NMFS Alaska Region, Juneau, AK.
- Savarese, D. M., C. M. Reiser, D. S. Ireland, and R. Rodrigues. 2010. Beaufort Sea vessel-based monitoring program. Pages 6-1 - 6-53 in D. W. Funk, D. S. Ireland, R. Rodrigues, and W. R. Koski, editors. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008, volume LGL Draft Final Report P1050-2.
- Scarlett, L., A. Fraas, R. Morgenstern, and T. Murphy. 2011. Managing Environmental, Health, and Safety Risks: A Comparative Assessment of the Minerals Management Service and Other Agencies.
- Scheffer, V. B. 1958. Seals, sea lions and walruses: a review of the Pinnipedia. Stanford University Press, Palo Alto, CA.
- Schenk, C. J., P. H. Nelson, T. R. Klett, P. A. Le, and C. P. Anderson. 2015. Assessment of unconventional (tight) gas resources in Upper Cook Inlet Basin, South-central Alaska. US Geological Survey.
- Schweder, T., and D. Sadykova. 2009. Information is gained increasingly fast in capture-recapture surveys - bowheads assessed by photographic surveys, and minke whales by genetic marking? Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.
- Schweder, T. D., D. Sadykova, D. Rugh, and W. R. Koski. 2010. Population estimates from aerial photographic surveys of naturally and variably marked bowhead whales. *Journal of Agricultural, Biological, and Environmental Statistics* 15(1):10-19.
- Scientific Fishery Systems Inc. 2009. 2008 underwater noise survey during construction pile driving, Port of Anchorage Marine Terminal Development Project, in support of Alaska Native Technologies, LLC. Prepared for U.S. Department of Transportation Maritime Administration, Port of Anchorage, and Integrated Concepts and Research Corporation.
- Serreze, M. C., and R. G. Barry. 2011. Processes and impacts of Arctic amplification: a research

- synthesis. *Global and Planetary Change* 77(1):85-96.
- Shelden, K. E., C. L. Sims, L. Vate Brattström, K. T. Goetz, and R. C. Hobbs. 2015a. Aerial surveys of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2014.
- Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015b. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. *Marine Fisheries Review* 77(2):1-32.
- Shelden, K. E. W., R. C. Hobbs, C. L. Sims, L. Vate Brattstrom, J. A. Mocklin, C. Boyd, and B. A. Mahoney. 2017. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016. NOAA National Marine Fisheries Service, Seattle, WA.
- Shelden, K. E. W., D. J. Rugh, K. T. Goetz, C. L. Sims, L. Vate Brattstrom, J. A. Mocklin, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2013. Aerial Surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. NOAA Technical Memo. NMFS-AFSC-263, 131 pp.
- Shelden, K. E. W., D. J. Rugh, B. A. Mahoney, and M. E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: Implications for a depleted population. *Marine Mammal Science* 19(3):529-544.
- Shelden, K. E. W., and P. R. Wade. 2019. Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 93 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.
- Shields, P., and A. Dupuis. 2017. Upper Cook Inlet Commercial Fisheries Annual Management Report, 2016, Fishery Management Report No. 17-05.
- Simmonds, M. P., and W. J. Elliott. 2009. Climate change and cetaceans: concerns and recent developments. *Journal of the Marine biological Association of the United Kingdom* 89(1):203-210.
- Simon, M., M. Johnson, and P. T. Madsen. 2012. Keeping momentum with a mouthful of water: behavior and kinematics of humpback whale lunge feeding. *Journal of Experimental Biology* 215(21):3786-3798.
- Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. *Polar Biology* 26(9):577-586.
- Širović, A., L. N. Williams, S. M. Kerosky, S. M. Wiggins, and J. A. Hildebrand. 2013. Temporal separation of two fin whale call types across the eastern North Pacific. *Marine Biology* 160(1):47-57.
- Sitkiewicz, S., W. Hetrick, K. Leonard, and S. Wisdom. 2018. 2018 Harvest Alaska Cook Inlet Pipeline Project Monitoring Program Marine Mammal Monitoring and Mitigation Report. Prepared for Harvest Alaska, LLC, 3800 Centerpoint Drive, Suite 1400, Anchorage, Alaska 99503 Submitted to National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, 1315 East West Highway, Silver Spring, MD 20910. Fairweather Science, 301 Calista Court, Anchorage, AK 99518.
- Slabbekoorn, H., N. Bouton, I. van Opzeeland, A. Coers, C. ten Cate, and A. N. Popper. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends in ecology & evolution* 25(7):419-427.

- SLR Consulting. 2017. Hilcorp Liberty Project Alaska Underwater and Airborne noise Modelling.
- Smith, M. A., M. S. Goldman, E. J. Knight, and J. J. Warrenchuk. 2017. Ecological Atlas of the Bering, Chukchi, and Beaufort Seas, 2nd Ed. Audubon Alaska, Anchorage, AK.
- Smith, T. G. 1976. Predation of ringed seal pups (*Phoca hispida*) by the Arctic fox (*Alopex agopus*). Canadian Journal of Zoology 54(10):1610-1616.
- Smith, T. G. 1981. Notes on the bearded seal, *Erignathus barbatus*, in the Canadian Arctic.
- Smith, T. G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. Bulletin Fisheries Research Board of Canada, 0660124637, Ottawa, Canada.
- Smith, T. G., and M. O. Hammill. 1981. Ecology of the ringed seal, *Phoca hispida*, in its fast ice breeding habitat. Canadian Journal of Zoology 59(6):966-981.
- Smith, T. G., and C. Lydersen. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. Polar Research 10(2):585-594.
- Smith, T. G., and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. Canadian Journal of Zoology 53(9):1297-1305.
- Smultea, M. A., K. Lomac-MacNair, P. Haase, and C. E. Bacon. 2014. 90-Day Report for Marine Mammal Monitoring and Mitigation during BPXA Liberty Shallow Geohazard Seismic and Seabed Mapping Survey, Beaufort Sea, Alaska, July-August 2014. .
- Smultea, M. A., J. R. Mobley Jr., D. Fertl, and G. L. Fulling. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. Gulf and Caribbean Research 20:75-80.
- Snyder-Conn, E., J. R. Garbarino, G. L. Hoffman, and A. Oelkers. 1997. Soluble trace elements and total mercury in Arctic Alaskan snow. Arctic:201-215.
- Sonune, A., and R. Ghate. 2004. Developments in wastewater treatment methods. Desalination 167:55-63.
- Soule, D. C., and W. S. Wilcock. 2013. Fin whale tracks recorded by a seismic network on the Juan de Fuca Ridge, Northeast Pacific Ocean. The Journal of the Acoustical Society of America 133(3):1751-1761.
- Southall, B. L. 2005. Shipping noise and marine mammals: a forum for science, management, and technology. Final report of the National and Atmospheric Administration (NOAA) International Symposium.
- Southall, B. L., J. Berkson, D. Bowen, R. Brake, J. Eckman, J. Field, R. Gisiner, S. Gregerson, W. Lang, and J. Lewandowski. 2009. Addressing the effects of human-generated sound on marine life: an integrated research plan for US federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology, Washington, DC 72pp.
- Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-521.
- Southall, B. L., R. J. Schusterman, and D. Kastak. 2000. Masking in three pinnipeds: Underwater, low-frequency critical ratios. The Journal of the Acoustical Society of America 108(3):1322-1326.
- Southall, B. L., R. J. Schusterman, and D. Kastak. 2003. Auditory masking in three pinnipeds: Aerial critical ratios and direct critical bandwidth measurements. The Journal of the

- Acoustical Society of America 114(3):1660-1666.
- St. Aubin, D., S. H. Ridgway, R. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: circulating levels in wild and semidomesticated *Tursiops truncatus*, and influence of sex, age, and season. *Marine Mammal Science* 12(1):1-13.
- Stafford, K. M., D. K. Mellinger, S. E. Moore, and C. G. Fox. 2007. Seasonal variability and detection range modeling of baleen whale calls in the Gulf of Alaska, 1999-2002. *Journal of the Acoustical Society of America* 122(6):3378-3390.
- Stoeger, A. S., D. Mietchen, S. Oh, S. de Silva, C. T. Herbst, S. Kwon, and W. T. Fitch. 2012. An Asian elephant imitates human speech. *Current Biology* 22(22):2144-2148.
- Stoker, S. W., and I. I. Krupnik. 1993. Subsistence whaling. Pages 579-629 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*. The Society for Marine Mammology, Lawrence, KS.
- Stone, G. S., S. K. Katona, A. Mainwaring, J. M. Allen, and H. D. Corbett. 1992. Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. Report of the International Whaling Commission 42(739-745).
- Sullivan, R. M. 1980. Seasonal occurrence and haul-out use in pinnipeds along Humboldt County, California. *Journal of Mammalogy* 61(4):754-760.
- Suydam, R., and J. C. George. 2012. Preliminary analysis of subsistence harvest data concerning bowhead whales (*Balaena mysticetus*) taken by Alaskan Natives, 1974 to 2011. Paper SC/64/AWMP8 presented to the IWC Scientific Committee.
- Suydam, R., J. C. George, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. International Whaling Commission-Scientific Committee, Tromso, Norway.
- Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayer, P. Leslie, and G. Sheffield. 2012. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2011. IWC Scientific Committee.
- Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayer, P. Leslie, and G. Sheffield. 2014. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2013 IWC Scientific Committee.
- Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayer, L. Pierce, and G. Sheffield. 2013. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2012. IWC Scientific Committee.
- Suydam, R., J. C. George, B. Person, D. Ramey, C. Hanns, R. Stimmelmayer, L. Pierce, and G. Sheffield. 2015. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2014. IWC Scientific Committee.
- Suydam, R., J. C. George, B. Person, D. Ramey, R. Stimmelmayer, T. Sformo, L. Pierce, and G. Sheffield. 2016. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2015 and other aspects of bowhead biology and science. International Whaling Commission.
- Suydam, R., J. C. George, B. Person, D. Ramey, R. Stimmelmayer, T. Sformo, L. Pierce, and G. Sheffield. 2017. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2016. International Whaling Commission.
- Sweeney, K., R. Towell, and T. Gelatt. 2018. Results of Steller Sea Lion Surveys in Alaska, June-July 2018. N. Department of Commerce, NMFS, AFSC, MML, editor, Seattle, WA.
- Teilmann, J., E. W. Born, and M. Acquarone. 1999. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. *Canadian*

- Journal of Zoology 77(12):1934-1946.
- Templin, W. D., and L. W. Seeb. 2004. Clues to Chinook salmon nearshore migration in southeast Alaska from estimates of stock composition in troll harvests Pages 72-73 in J. Irvine, L. W. Seeb, U. Shigehiko, N. Varnavskaya, and R. Wilomt, editors. Workshop on application of stock identification in defining marine distribution and migration of salmon, Honolulu, Hawaii, November 1-2, 2003. NPAFC technical report 5. North Pacific Anadromous Fish Commission, Vancouver, British Columbia, Canada.
- Thewissen, J. G. M., J. George, C. Rosa, and T. Kishida. 2011. Olfaction and brain size in the bowhead whale (*Balaena mysticetus*). *Marine Mammal Science* 27(2):282-294.
- Thode, A., K. H. Kim, C. R. Greene Jr, and E. Roth. 2010. Long range transmission loss of broadband seismic pulses in the Arctic under ice-free conditions. *The Journal of the Acoustical Society of America* 128(4):EL181-EL187.
- Thoman, R., and J. E. Walsh. 2019. Alaska's Changing Environment: Documenting Alaska's Physical and Biological Changes Through Observations. International Arctic Research Center, University of Alaska Fairbanks.
- Thomas, J. A., R. A. Kastelein, and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. *Zoo Biology* 9(5):393-402.
- Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *The Journal of the Acoustical Society of America* 92(6):3051-3057.
- Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. W. J. Richardson, J. C. R. Greene, C. I. Malme, and D. H. Thomson, editors. *Marine Mammals and Noise*. Academic Press, San Diego, California.
- Thorson, J. T., M. Fossheim, F. J. Mueter, R. R. Lauth, R. Primicerio, B. Husson, J. Marsh, A. Dolgov, and S. G. Zador. 2019. Comparison of Near-bottom Fish Densities Show Rapid Community and Population Shifts in the Bering and Barents Seas. NOAA Arctic Report Card 2019.
- Tollit, D., J. Harwood, C. Booth, L. Thomas, L. New, and J. Wood. 2016. Cook Inlet Beluga Whale PCoD Expert Elicitation Workshop Report. Prepared by SMRU Consulting North America for NOAA Fisheries. SMRUC-NA-NOAA0915.
- Tomilin, A. 1967. Mammals of the USSR and adjacent countries. *Cetacea* 9:666-696.
- Tougaard, J., J. Carstensen, J. Teilmann, H. Skov, and P. Rasmussen. 2009. Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.)). *The Journal of the Acoustical Society of America* 126(1):11-14.
- Treacy, S. D., J. S. Gleason, and C. J. Cowles. 2006. Offshore distances of bowhead whales (*Balaena mysticetus*) observed during fall in the Beaufort Sea, 1982-2000: an alternative interpretation. *Arctic* 59(1):83-90.
- Trombulak, S. C., K. S. Omland, J. A. Robinson, J. J. Lusk, T. L. Fleischner, G. Brown, and M. Domroese. 2004. Principles of conservation biology: recommended guidelines for conservation literacy from the education committee of the Society for Conservation Biology. *Conservation Biology* 18(5):1180-1190.
- Tucker, S., M. E. Thiess, J. F. T. Morris, D. Mackas, W. T. Peterson, J. R. Candy, T. D. Beacham, E. M. Iwamoto, D. J. Teel, M. Peterson, and M. Trudel. 2015. Coastal distribution and consequent factors influencing production of endangered Snake River sockeye salmon. *Transactions of the American Fisheries Society* 144(1):107-123.

- Tucker, S., M. Trudel, D. W. Welch, J. R. Candy, J. F. T. Morris, M. E. Thiess, C. Wallace, and T. D. Beacham. 2012. Annual coastal migration of juvenile Chinook salmon: static stock-specific patterns in a highly dynamic ocean. *Marine Ecology Progress Series* 449:245–262.
- Tyack, P. L. 1999. Communication and cognition. *Biology of marine mammals*:287-323.
- Tyack, P. L. 2000. Functional aspects of cetacean communication. Pages 270-307 *in* J. Mann, R. C. Connor, P. L. Tyack, and H. Whitehead, editors. *Cetacean societies: field studies of dolphins and whales*. The University of Chicago Press, Chicago, Illinois.
- Tyack, P. L. 2009. Human-generated sound and marine mammals. *Physics Today* 62(11):39-44.
- Tynan, C. T., and D. P. Demaster. 1997. Observations and predictions of Arctic climatic change: Potential effects on marine mammals. *Arctic* 50(4):308-322.
- U.S. Committee on the Marine Transportation System. 2016. A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic. A Report to the President. Washington, D.C., 52 p.
- Urick, R. J. 1983. *Principles of Underwater Sound*. McGraw-Hill.
- URS, Corp. 2007. Port of Anchorage marine terminal development project underwater noise survey test pile driving program. Prepared by Integrated Concepts & Research Corporation.
- USACE-DOER. 2001. Characterization of Underwater Sounds produced by Bucket Dredging Operations. .
- USACE. 2008. Environmental assessment and finding of no significant impact: Anchorage Harbor dredging and disposal. A. Division, editor. U.S. Army Corps of Engineers, Anchorage, Alaska.
- USACE. 2015. Dredge Plume Dynamics in New York/New Jersey Harbor. Summary of suspended sediment plume surveys performed during harbor deepening. April 2015. New York District Army Corps of Engineers. 133 pp.
- USACE. 2019. Annual marine mammal report for the Alaska District's Port of Alaska maintenance dredging for the 2018 dredging season. Memorandum for the National Marine Fisheries Service, Protected Resources Division.
- USDOT. 2006. Construction Noise Handbook, Final Report August 2006. Prepared for the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. by the U.S. Department of Transportation, Research and Innovative Technology Administration, John A. Volpe National Transportation Systems Center, Environmental Measurement and Modeling Division, Acoustics Facility, Cambridge, MA 02142. https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/.
- van der Hoop, J. M., P. Corkeron, J. Kenney, S. Landry, D. Morin, J. Smith, and M. J. Moore. 2016. Drag from fishing gear entangling North Atlantic right whales. *Marine Mammal Science* 32(2):619-642.
- Van Parijs, S. M. 2003. Aquatic mating in pinnipeds: A review. *Aquatic Mammals* 29(2):214-226.
- Van Parijs, S. M., and C. W. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, *Erignathus barbatus*. *Animal Behaviour* 72(6):1269-1277.
- Van Parijs, S. M., K. M. Kovacs, and C. Lydersen. 2001. Spatial and temporal distribution of vocalising male bearded seals: Implications for male mating strategies. *Behaviour* 138(7):905-922.
- Van Parijs, S. M., C. Lydersen, and K. M. Kovacs. 2003. Vocalizations and movements suggest

- alternative mating tactics in male bearded seals. *Animal Behaviour* 65(2):273-283.
- Van Parijs, S. M., C. Lydersen, and K. M. Kovacs. 2004. Effects of ice cover on the behavioural patterns of aquatic-mating male bearded seals. *Animal Behaviour* 68(1):89-96.
- Vanderlaan, A. S. M., and C. T. Taggart. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Marine Mammal Science* 23(1):144-156.
- Vincent-Lang, D., and I. Queral. 1984. Susitna Hydro aquatic studies. Report 3: Aquatic habitat and instream flow. Chapter 5: Eulachon spawning habitat in the Lower Susitna River.
- Wade, P. R., T. J. Quinn II, J. Barlow, C. S. Baker, A. M. Burdin, J. Calambokidis, P. J. Clapham, E. Falcone, J. K. B. Ford, C. M. Gabriele, R. Leduc, D. K. Mattila, L. Rojas-Bracho, J. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, and M. Yamaguchi. 2016. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas. Paper SC/66b/IA21 submitted to the Scientific Committee of the International Whaling Commission, June 2016, Bled, Slovenia. Pages 42 p. *in*. International Whaling Commission.
- Walsh, J. E. 2008. Climate of the Arctic marine environment. *Ecological applications* 18(2 Supplement):S3-S22.
- Wang, M., and J. E. Overland. 2009. A sea ice free summer Arctic within 30 years? *Geophysical Research Letters* 36:L07502.
- Wang, Z., Y. Wu, G. Duan, H. Cao, J. Liu, K. Wang, and D. Wang. 2014. Assessing the underwater acoustics of the world's largest vibration hammer (OCTA-KONG) and its potential effects on the Indo-Pacific humpbacked dolphin (*Sousa chinensis*). *PLoS One* 9(10):e110590.
- Wartzok, D., and D. R. Ketten. 1999. Marine mammal sensory systems. *Biology of marine mammals* 1:117.
- Wartzok, D., A. N. Popper, J. Gordon, and J. Merrill. 2003. Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. *Marine Technology Society Journal* 37(4):6-15.
- Watanabe, Y., C. Lydersen, K. Sato, Y. Naito, N. Miyazaki, and K. M. Kovacs. 2009. Diving behavior and swimming style of nursing bearded seal pups. *Marine Ecology Progress Series* 380:287-294.
- Wathne, J. A., T. Haug, and C. Lydersen. 2000. Prey preference and niche overlap of ringed seals (*Phoca hispida*) and harp seals (*P. groenlandica*) in the Barents Sea. *Marine Ecology Progress Series* 194:233-239.
- Watkins, W., K. Moore, and P. Tyack. 1985. Sperm whales acoustic behaviour in the Southeast Caribbean. *Cetology* 49:1-15.
- Watkins, W. A. 1981. Activities and underwater sounds of fin whales. *Scientific Reports of the Whales Research Institute* 33:83-117.
- Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon. 2000. Seasonality and distribution of whale calls in the North Pacific. *Oceanography* 13(1):62-67.
- Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). *The Journal of the Acoustical Society of America* 82(6):1901-1912.
- Watson, R. T., and D. L. Albritton. 2001. Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change. Cambridge

- University Press.
- Weilgart, L., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galapagos Islands. *Canadian Journal of Zoology* 71(4):744-752.
- Weilgart, L. S. 2007. A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology* 20(2).
- Weller, D. W., N. Takanawa, H. Ohizumi, N. Funahashi, O. A. Sychenko, A. M. Burdin, A. R. Lang, and J. Brownell R.L. 2016. Gray whale migration in the western North Pacific: further support for a Russia-Japan connection. In Annex F to SC/66b/BRG16 report of the IWC Scientific Committee, Bled, Slovenia, June 2016.
- Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. *Marine Ecology Progress Series* 242:295-304.
- Whitehead, H., and T. Arnbohm. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. *Canadian Journal of Zoology* 65(4):913-919.
- Wieting, D. 2016. Interim Guidance on the Endangered Species Act Term "Harass". National Marine Fisheries Service, Office of Protected Resources. Silver Spring, MD. October 21, 2016.
- Wiggin, M. 2017. Alaska's Oil and Gas Industry: Overview and Activity Update, Commonwealth North. Alaska Department of Natural Resources.
- Williams, M. T., J. A. Coltrane, and C. J. Perham. 2001. On-ice location of ringed seal structures near Northstar, December 1999 and May 2000. W. J. Richardson, and M. T. Williams, editors. *Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2000-2001*
- Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. *Journal of Cetacean Research and Management* 4(3):305-310.
- Williams, R., and D. P. Noren. 2009. Swimming speed, respiration rate, and estimated cost of transport in adult killer whales. *Marine Mammal Science* 25(2):327-350.
- Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling. Pages 387-407 in J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*, volume Spec. Publ. No. 2. Society of Marine Mammalogy.
- WSDOT. 2019. Biological Assessment Preparation Manual BA Manual Chapter 7. Construction Noise Impact Assessment. Chapter Updated August 2019.
https://www.wsdot.wa.gov/sites/default/files/2018/01/18/Env-FW-BA_ManualCH07.pdf.
- Wursig, B., and C. Clark. 1993. Behavior. Pages 157-199 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The Bowhead Whale*. The Society for Marine Mammalogy, Lawrence, KS.
- Wursig, B., E. Dorsey, W. Richardson, and R. Wells. 1989. Feeding, aerial and play behaviour of the bowhead whale, *Balaena mysticetus*, summering in the Beaufort Sea. *Aquatic Mammals* 15(1):27-37.
- Wursig, B., C. R. Greene Jr, and T. A. Jefferson. 2000. Development of an air bubble curtain to reduce underwater noise of percussive piling. *Marine Environmental Research* 49(1):79-93.
- Yablokov, A. V. 1994. Validity of whaling data. *Nature* 367(6459):108.
- Zeh, J. E., D. Poole, G. Miller, W. Koski, L. Baraff, and D. Rugh. 2002. Survival of bowhead whales, *Balaena mysticetus*, estimated from 1981-1998 photoidentification data.

- Biometrics 58(4):832-840.
- Zeh, J. E., and A. E. Punt. 2005. Updated 1978-2001 abundance estimates and their correlations for the BeringChukchi-Beaufort Seas stock of bowhead whales. Pages 10 *in*. submitted to International Whaling Comission Scientific Committee.
- Zerbini, A. N., P. J. Clapham, and P. R. Wade. 2010. Assessing plausible rates of population growth in humpback whales from life-history data. *Marine Biology* 157(6):1225-1236.
- Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off Western Alaska and the central Aleutian Islands. *Deep Sea Research Part I-Oceanographic Research Papers* 53(11):1772-1790.