



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, AK 99802-1668

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

For the Alaska Liquefied Natural Gas (LNG) Project

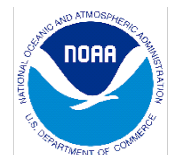
NMFS Consultation Number: AKRO-2025-02084

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	n/a	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	No	No	n/a
Humpback whale, Mexico DPS (<i>Megaptera novaeangliae</i>)	Threatened	Yes	No	No	n/a
North Pacific right whale (<i>Eubalaena japonica</i>)	Endangered	No	No	n/a	n/a
Sperm whale (<i>Physeter macrocephalus</i>)	Endangered	Yes	n/a	No	n/a
Ringed seal, Arctic subspecies (<i>Phoca (pusa) hispida hispida</i>)	Threatened	Yes	No ¹	No	n/a

¹ On September 26, 2024, the U.S. District Court for the District of Alaska vacated the critical habitat designations for ringed seals and bearded seals under the ESA and remanded the rules to NMFS for further consideration (*State of Alaska v. Nat'l Marine Fisheries Serv.*, Case No. 3:23-cv-00032-SLG, 2024 WL 4298114 (D. Alaska Sept. 26,



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?
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	Threatened	Yes	No ¹	No	n/a
Steller sea lion, Western DPS (<i>Eumetopias jubatus</i>)	Endangered	Yes	No	No	n/a
Cook Inlet beluga whale (<i>Delphinapterus leucas</i>)	Endangered	Yes	No	No	n/a
Gray whale, Western North Pacific DPS (<i>Eschrichtius robustus</i>)	Endangered	No	n/a	n/a	n/a
Sei whale (<i>Balaenoptera borealis</i>)	Endangered	No	n/a	n/a	n/a
Chinook salmon (<i>Oncorhynchus tshawytscha</i>) ESU					
Lower Columbia River	Threatened	No	n/a	n/a	n/a
Upper Columbia River Spring	Threatened	No	n/a	n/a	n/a
Puget Sound	Threatened	No	n/a	n/a	n/a
Snake River Fall	Threatened	No	n/a	n/a	n/a
Snake River Spring/Summer	Threatened	No	n/a	n/a	n/a
Upper Willamette River	Threatened	No	n/a	n/a	n/a
Steelhead trout (<i>Oncorhynchus mykiss</i>) DPS					
Lower Columbia River	Threatened	No	n/a	n/a	n/a
Middle Columbia River	Threatened	No	n/a	n/a	n/a
Snake River Basin	Threatened	No	n/a	n/a	n/a
Upper Columbia River	Threatened	No	n/a	n/a	n/a
Upper Willamette River	Threatened	No	n/a	n/a	n/a
Puget Sound	Threatened	No	n/a	n/a	n/a

2024)). NMFS and the Center for Biological Diversity appealed that decision, but NMFS has since moved to dismiss. In the interim, while the Center for Biological Diversity's appeal remains active, our biological opinions and letters of concurrence under section 7(a)(2) of the ESA will continue to address effects to ringed seal and bearded seal critical habitat, when requested, so that action agencies have the benefit of NMFS's analysis of the consequences of proposed actions on the critical habitat in the event that the appeal is successful, even though the designations are currently not in effect.

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:


Jonathan M. Kurland
Regional Administrator

Date: October 31, 2025

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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 1μPa	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.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 FR 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to NMFS's existing practice in implementing section 7(a)(2) of the Act. (84 FR at 45015; 89 FR at 24268). We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

In this document, the action agencies are the NMFS Office of Protected Resources – Permits and Conservation Division ("Permits Division" or OPR) and the Federal Energy Regulatory Commission (FERC). This consultation is a reinitiation of the biological opinion for the Alaska liquefied natural gas (LNG) project previously issued on June 3, 2020 (AKRO-2018-01319) to account for changes to the project proposed by 8 Star Alaska, LLC (8 Star Alaska) in 2024 and 2025, as well as other recent information. The Permits Division proposes to issue 8 Star Alaska, a subsidiary of the Alaska Gasoline 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 LNG pipeline. FERC proposes to authorize 8 Star Alaska 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 AKR's biological opinion (opinion) on the effects of these proposed actions on endangered and threatened species and designated critical habitat.

The opinion and ITS were prepared by NMFS AKR 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 the Alaska 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*), Cook Inlet beluga whale critical habitat, 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*), Western North Pacific DPS and Mexico DPS humpback whale critical habitat, 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 (pusa) hispida hispida*), Arctic ringed seal critical habitat,¹ threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*), Beringia DPS bearded seal critical habitat,¹ endangered Western DPS Steller sea lion (*Eumetopias jubatus*), Steller sea lion critical habitat, and the following 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 8 Star Alaska in the revised IHA application for the proposed activities in Prudhoe Bay (AGDC 2024) and the petition for an LOA for the proposed activities in Cook Inlet (AGDC 2025), the Environmental Impact Statement (EIS) (FERC 2020) and Biological Assessment (BA) by FERC published on June 28, 2019 (FERC 2019), the proposed LOA (90 FR 35762; July 29, 2025), the updated project proposals, email and telephone conversations between NMFS AKR, NMFS Permits Division, FERC, and 8 Star Alaska, and other sources of information. A complete record of this consultation is on file at NMFS's Alaska office.

1.2 Consultation History

- January 5, 2018: 8 Star Alaska submitted a Letter of Authorization (LOA) petition (Cook Inlet)
- October 2, 2018: 8 Star Alaska submitted a revised LOA petition (Cook Inlet)
- March 28, 2019: 8 Star Alaska submitted an IHA application (Prudhoe Bay)
- May 21, 2019: 8 Star Alaska submitted a revised IHA application (Prudhoe Bay)

- June 28, 2019: FERC released a Draft Environmental Impact Statement (ITS), including a BA
- June 28, 2019: The proposed Incidental Take Regulation (Cook Inlet) published in the Federal Register
- September 16, 2019: 8 Star Alaska submitted a revised IHA application (Prudhoe Bay)
- October 31, 2019: 8 Star Alaska submitted a revised IHA application (Prudhoe Bay)
- August 30, 2019: NMFS AKR deemed the consultation package complete
- November 2019: NMFS AKR, FERC, and 8 Star Alaska agreed to extend the ESA section 7 consultation from January 1, 2020, to June 4, 2020
- March 6, 2020: FERC issued a final EIS
- April 29, 2020: 8 Star Alaska agreed to a revised set of mitigation measures
- May 22, 2020: NMFS Permits Division (OPR) requested consultation with NMFS AKR
- June 3, 2020: NMFS AKR issued a Biological Opinion for the proposed actions
- August 17, 2020: NMFS OPR issued regulations for the taking of marine mammals incidental to the Alaska LNG project in Cook Inlet, Alaska, over the course of five years (2020-2025) (85 FR 50720, August 17, 2020)
- September 21, 2020: NMFS OPR issued LOA (Cook Inlet) (85 FR 59291, September 21, 2020)
- February 22, 2021: NMFS OPR issued IHA (Prudhoe Bay)
- June 21, 2024: 8 Star Alaska submitted revised IHA application (Prudhoe Bay) to NMFS OPR
- December 5, 2024: 8 Star Alaska submitted revised LOA petition (Cook Inlet) to NMFS OPR
- April 8, 2025: 8 Star Alaska addressed comments and submitted revised LOA petition (Cook Inlet) to NMFS Permit Division (OPR)
- April 18, 2025: NMFS OPR issued a proposed incidental harassment authorization for takes of marine mammals incidental to construction of the Alaska LNG project in Prudhoe Bay, Alaska (90 FR 16600, April 18, 2025)
- July 2, 2025: FERC confirms it will remain an action agency for the revised Biological Opinion, and that there are no changes to any FERC actions or authorizations related to the project
- July 11, 2025: NMFS OPR requested reinitiation of ESA Section 7 consultation with NMFS AKR
- July 29, 2025: NMFS OPR issued a proposed rule for regulations for the taking of marine mammals incidental to the Alaska LNG Project in Cook Inlet, Alaska, over the course of 5 years (2026-2030) (90 FR 35762, July 20, 2025)

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 CFR 402.02).

This opinion considers the effects of the NMFS Permits Division’s Marine Mammal Protection Act (MMPA) authorization to 8 Star Alaska for incidental takes of marine mammals, and FERC’s authorization to 8 Star Alaska 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 EIS (FERC 2019; FERC 2020)². To the extent that there are differences in the project description between the EIS and 2020 biological opinion and this opinion, the project description herein is also based on updated project information from 8 Star Alaska, primarily the IHA application and LOA petition.

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 8 Star Alaska. Consultation may be required if future federal actions related to the AK LNG project occur or if there are unanticipated effects related to pipeline operations and maintenance that were not considered in this opinion.

² <https://www.ferc.gov/industries-data/natural-gas/environment/final-environmental-impact-statement-feis#>
Accessed August 20, 2025.

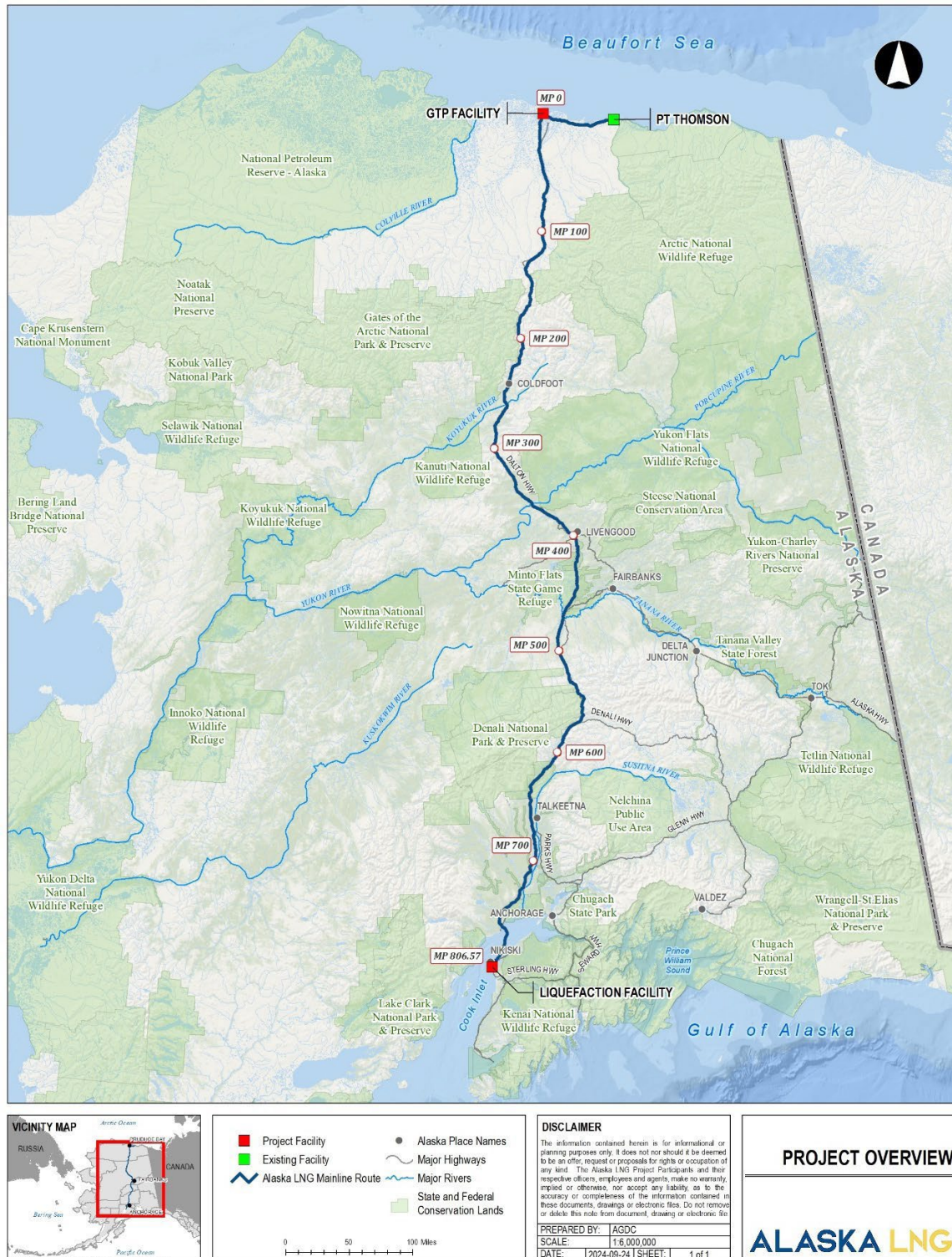


Figure 1. Map of the proposed Alaska LNG pipeline project (AGDC 2025)

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	Activities and Duration		
		July 1 – December 30 (First Half Year 1)	January – June 30 (Second Half Year 1)	Non-IHA Activities (After Year 1)
Causeway Widening	Haul and deposit gravel ¹			*
DH4 Construction and Use	Gravel hauling and deposition ₁			*
	Install sheet pile walls (pile driving) ²	*	*	
	Install mooring dolphins (pile driving) ²	*		
	Install bag armor ¹	*		
	Excavate overfill / re-compact gravel ³			*
	Prepare seabed / level berths (screeding) ⁴			*
Barge Bridge & Abutments Construction and Use	Haul and deposit gravel ⁵	*		
	Install bulkhead (pile driving) ₅	*	*	
	Install mooring dolphins (pile driving) ⁵	*		
	Prepare barge bridge seabed pad ⁶			*
	Install / remove barge bridge ⁷			*
Sealift	Vessel transit to Prudhoe Bay ₈			*
	Offload materials / modules at DH4 ⁹			*

¹ Planned for July-September

² Planned for September-October outside of Nuiqsut whaling season, contingency timeframe February-April

³ Planned for May-June

⁴ Planned for July just after ice recedes

⁵ Planned for July-August, contingency timeframe February-April

⁶ Initial preparation planned through the ice in February-April the year of the IHA, with additional minor smoothing in the subsequent years

⁷ Barge bridge to be installed at the beginning of the open water season and removed each fall beginning in Year 2

⁸ Vessels would transit Chukchi Sea and Beaufort Sea July-September Year 2 through Year 4

⁹ Materials offloading (smaller modules, equipment, supplies) planned for August-September in Years 2-5; GTP module offloading planned for August-September in Years 2-5



Figure 2. Existing conditions at West Dock in Prudhoe Bay, Alaska (AGDC 2024)

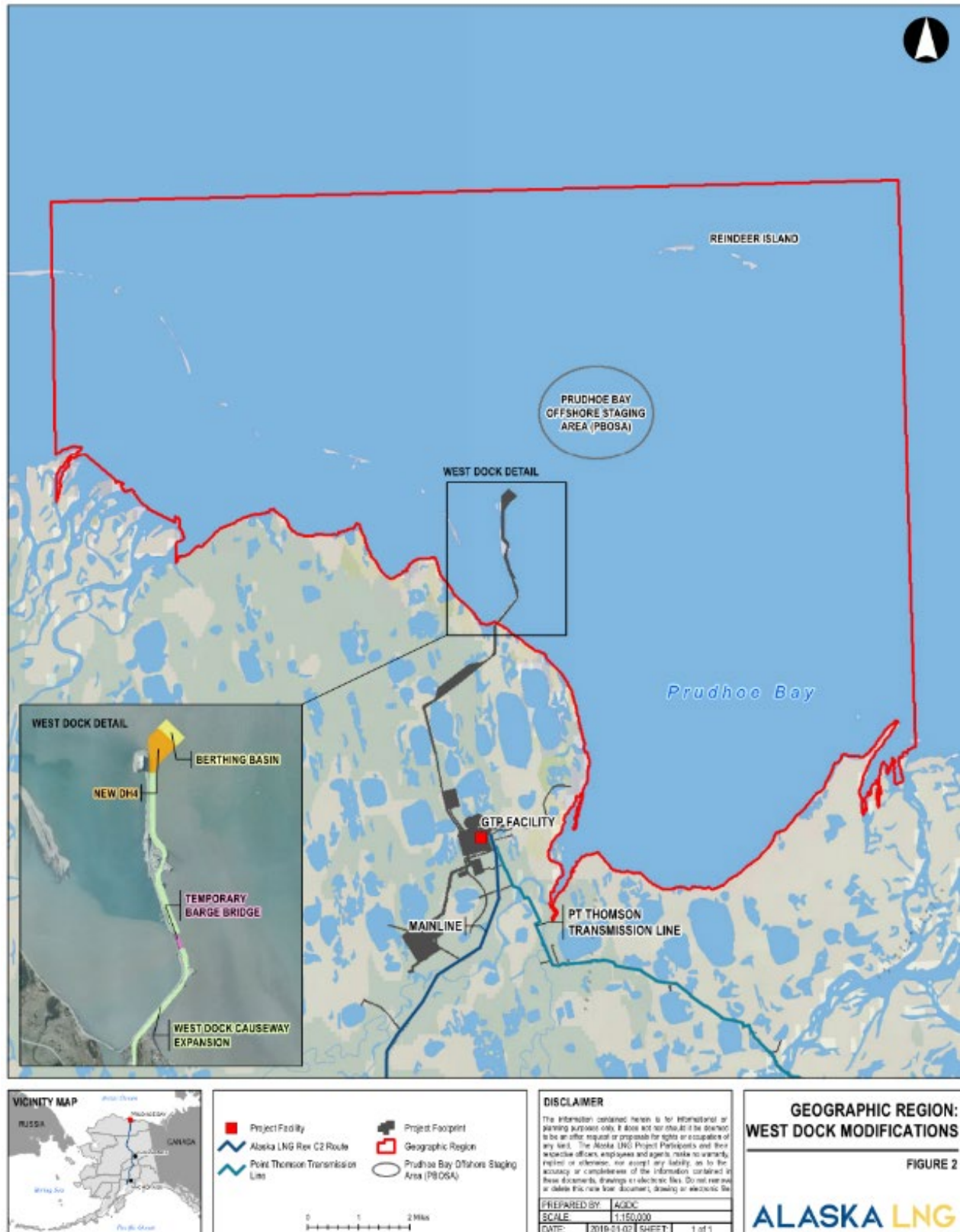


Figure 3. Proposed modifications to West Dock, Prudhoe Bay, Alaska, for the Alaska LNG project (AGDC 2024)



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. After Year 1, 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.

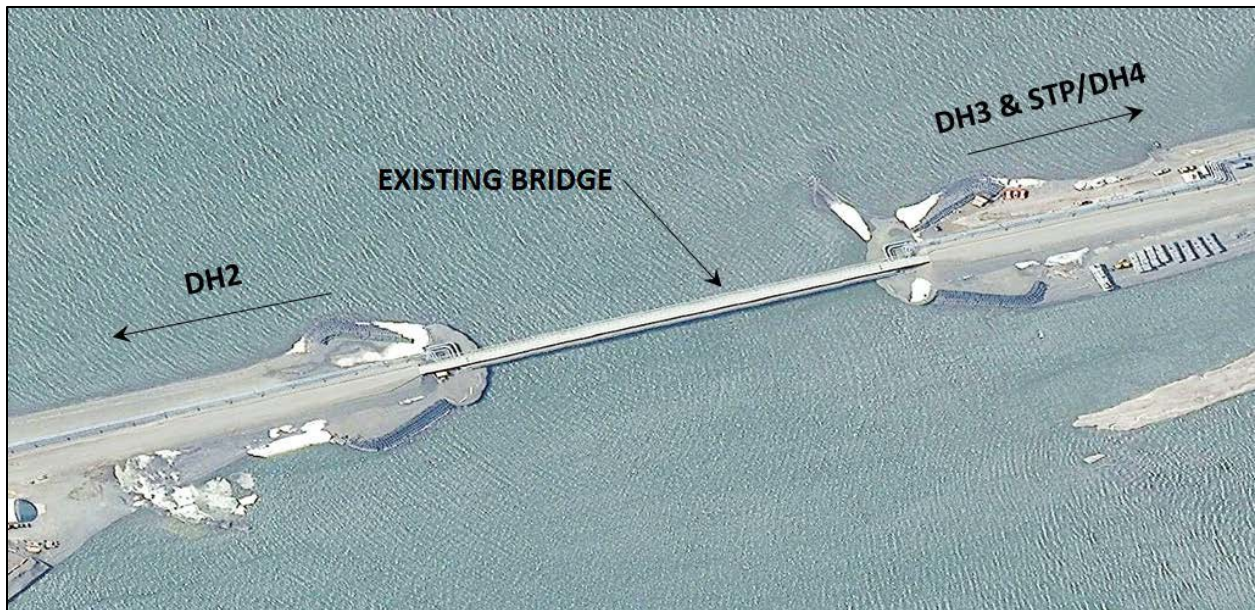


Figure 5. Existing conditions at the West Dock breach/bridge (AGDC 2024)

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 DH3 to DH4.

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 strikes	9
Bulkhead	25-in sheet pile ^{a,c}	Vibratory	422	12	24.0 min	36
Mooring Dolphins	48-in pipe pile ^{a,c}	Impact	12	1.25	1,000 strikes	10
Mooring Dolphins	14-in H pile (temp) ^{a,d}	Vibratory	48	4	13.4 min	12
Totals	--	--	694	--	--	67

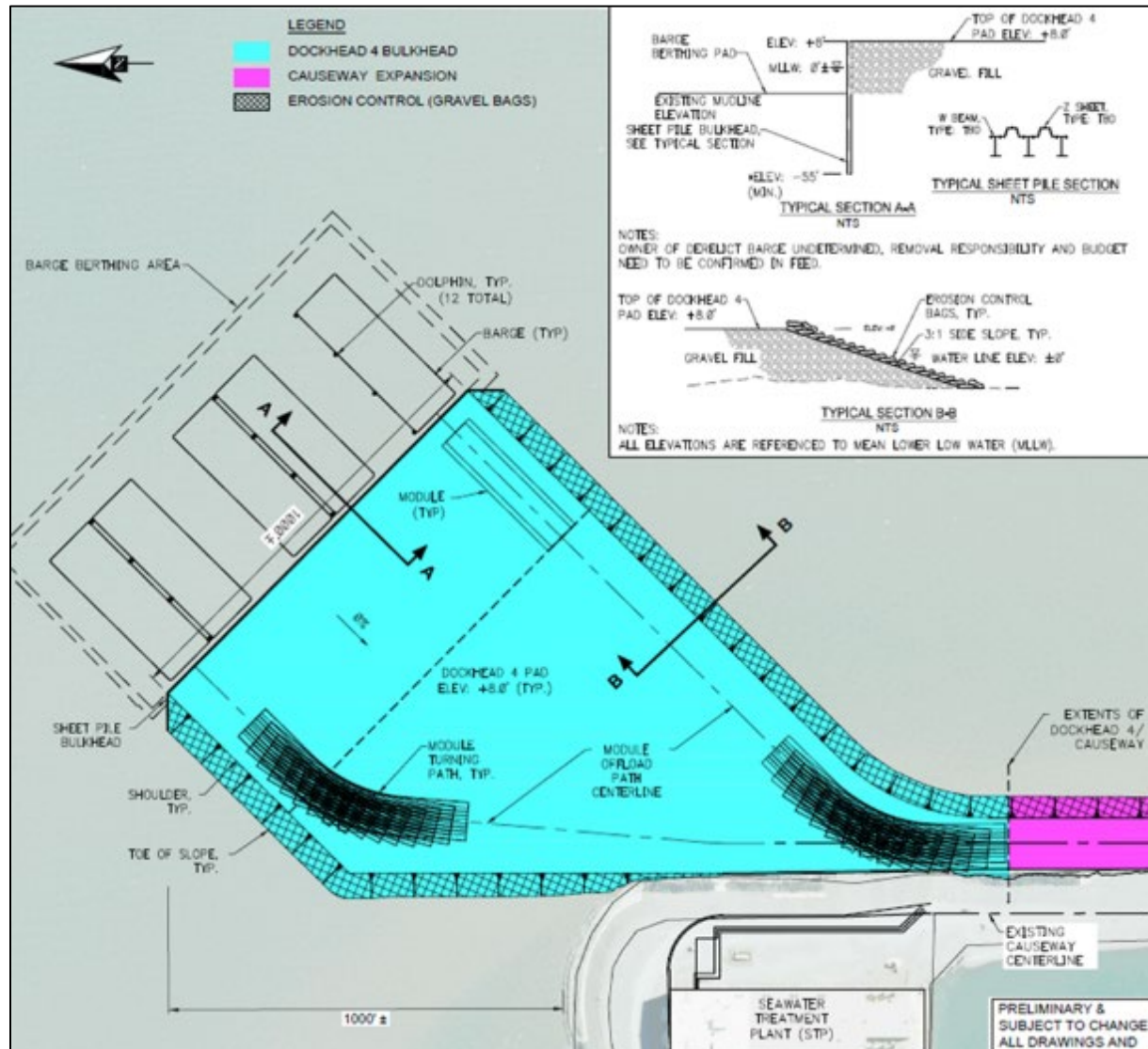
^a All piles are steel.

^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.



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 11.5-in 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.

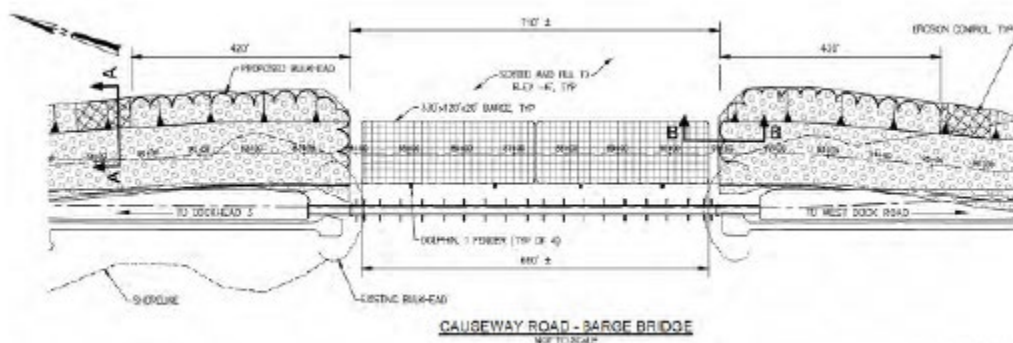


Figure 7. Proposed temporary barge bridge in Prudhoe Bay (AGDC 2024)

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 minutes	23
	Tail wall	14-in H pile ^c	Impact	4	22	1,000 strikes	1
		19.69-in sheet pile ^a	Vibratory	345	16	18.9 minutes	23
	Total	--	--	699	--	--	47
North Abutment	Dock face	14-in H pile ^c	Impact	--	--	--	--
		19.69-in sheet pile ^a	Vibratory	353	16	18.9 minutes	24
	Tail wall	14-in H pile ^c	Impact	4	22	1,000 strikes	1
		19.69-in sheet pile ^a	Vibratory	256	16	18.9 minutes	17
	Total	--	--	613	--	--	42
Total	All	--	--	1,312	--	--	89

^a Steel sheet piles expected to be PS27.5 Type with width of 19.69 in each, 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 an estimated depth 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-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

^a All piles are steel.

^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.

^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.

^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.

^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.

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.

Use after Construction/De-commissioning

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. Other on-land activities will occur as part of the action but are not expected to have any effects on ESA listed marine mammals under NMFS jurisdiction.

2.1.1.2 Cook Inlet

8 Star Alaska 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. 8 Star Alaska 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 verify the marine mammal monitoring and mitigation zones.

Table 8. Project schedule for Cook Inlet activities

Project Component / Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Marine Terminal					
Site Preparation Activities, Temporary MOF Construction	✓	✓			
Dredging, Complete Temporary MOF, Construct Mainline MOF	✓	✓			
Commence Installation of Trestle and Berths, Quadropod Installation		✓	✓	✓	
Complete Installation of Trestle, Continue Installation of Berths, Commence Installation of PLF Modules, Berths, and Mooring Dolphins			✓	✓	✓
Complete Installation of PLF					✓
MOF Reclamation/Demobilization					✓
Mainline Offshore Cook Inlet Spread					
Construct Shore Crossings and Nearshore Pipeline			✓	✓	
Complete Offshore Pipeline Construction, Hydrotest, and Final Tie-In				✓	✓



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.

There is no pile driving associated with constructing the Lo-Lo Berth, other than construction of the quay. 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 season 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)	Hammer	Method	Days ^a	Months ^b
2	quay ^c	1	470	Vibratory/Impact ^c	Marine	10	Apr-May
2	Ro-Ro ramp ^c	1	200	Vibratory/Impact ^c	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 percent 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, which will require dynamic positioning.

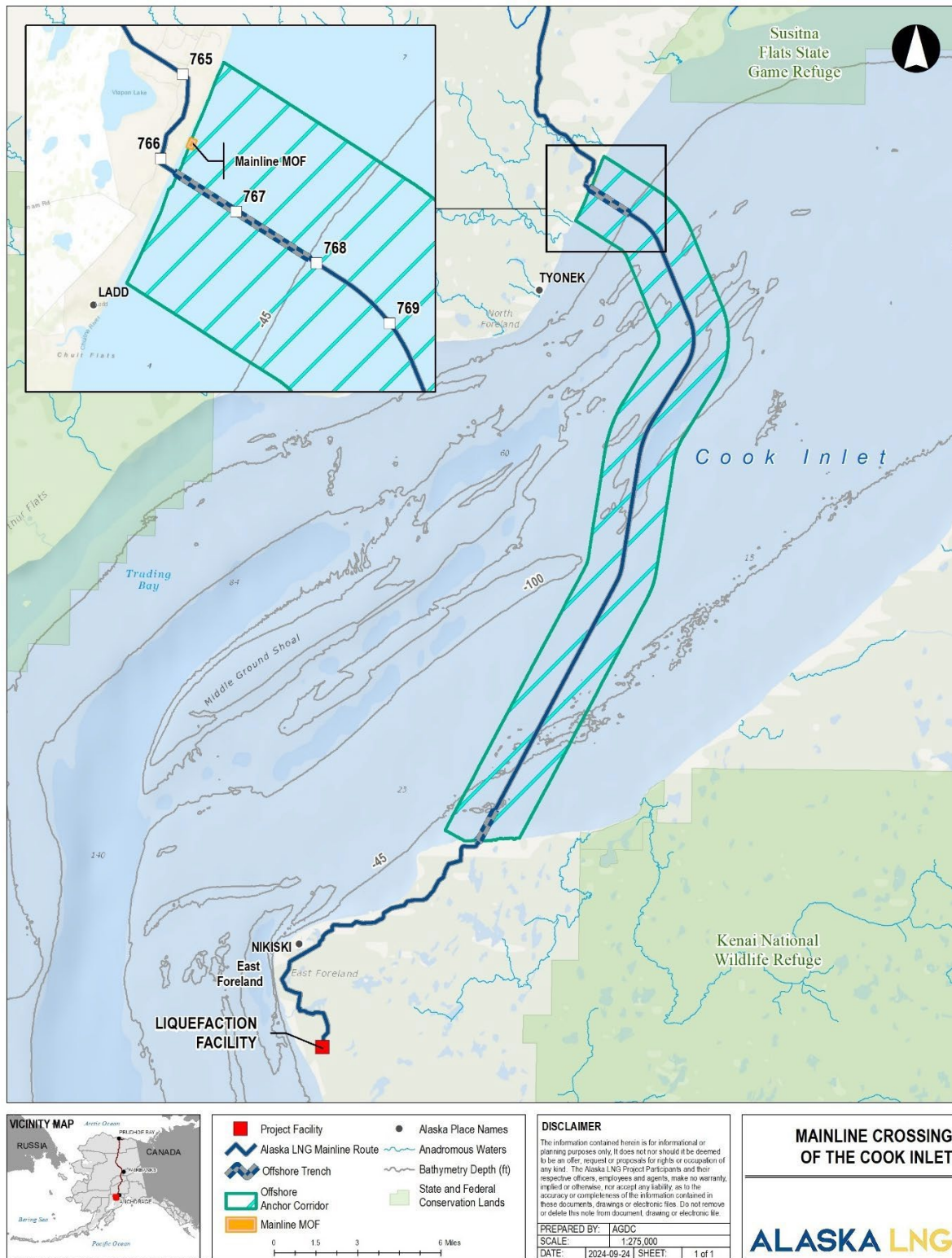


Figure 9. Mainline Crossing of Cook Inlet (AGDC 2025)

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
^a Additional 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 of 200 kHz and 400 kHz.
- Side-scan sonar system planned for use during this program operates at a frequency of 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 ¹	Operating Frequency (kHz)	SPL Source Level (dB re 1 µPa m) ³
Single Beam Echosounder	Echotrac CV-100	>200 ^{4,5}	175 ^{4,5}
Multibeam Echosounder	R2Sonic 2024	200-400 ²	196 ^{4,5}
Side-scan Sonar	EdgeTech 4200	400 ^{4,5}	205 ^{4,5}
¹ Source: Sonic 2024-V Manual. ² SPL = Sound pressure level. ³ Source: Crocker and Fratantonio, 2016. ⁴ BOEM, 2023.			

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 (ft)		Overcut (ft)	Trench Slope (Depth: Width)	Subsea Trench Cross Sectional Area (square ft)	Seafloor Area Trenched	
	To -35 ft MLLW	To -45 ft MLLW				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 (ft)		Trench Slope (Depth: Width)	Trench Width (ft)	Seafloor Area Trenched	
	To -35 ft MLLW	To -45 ft MLLW			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 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. 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.

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 (Years 3 and 4). The construction season extends 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 year 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 anchors to move (Table 14), and the estimated time required to retrieve and reset each anchor (approximately 30 minutes per anchor to retrieve and reset). A break-down of activities per year 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 Season 4.
- Tie-in the offshore section to the buried nearshore sections on both sides of the Cook Inlet.
- Flood, hydrotest, and dry the Mainline pipeline 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 (Figure 10). Primary components of the Marine Terminal include a PLF and the Temporary MOF (Figure 11).

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 11 and Figure 12, and are described as follows.

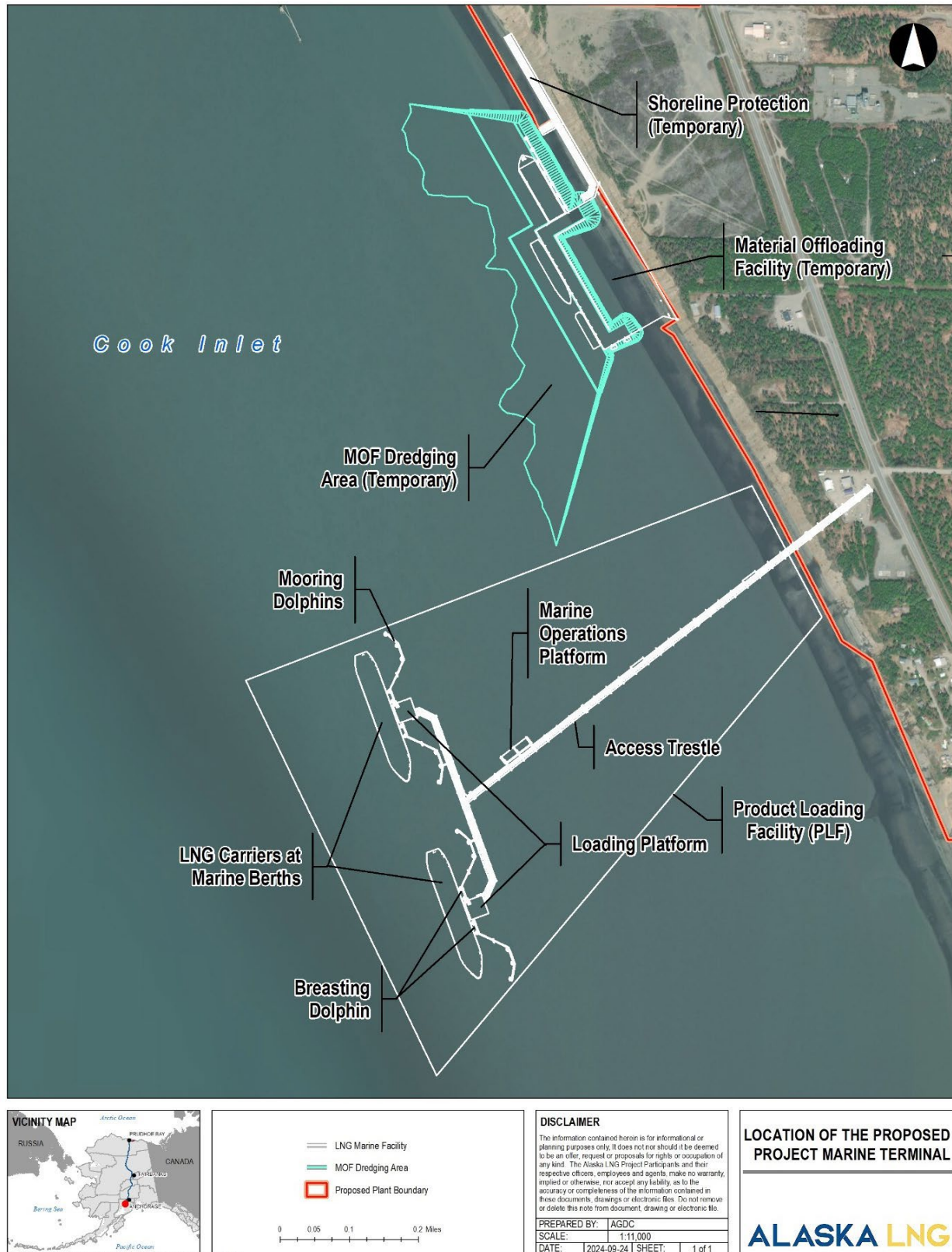


Figure 10. Location of Proposed Project Marine Terminal (AGDC 2025)

- **PLF Loading Platforms** – Two loading platforms, one located at either end of the north-south portion of the trestle (Figure 11), 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 (Figure 12) 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 (Figure 11) 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.

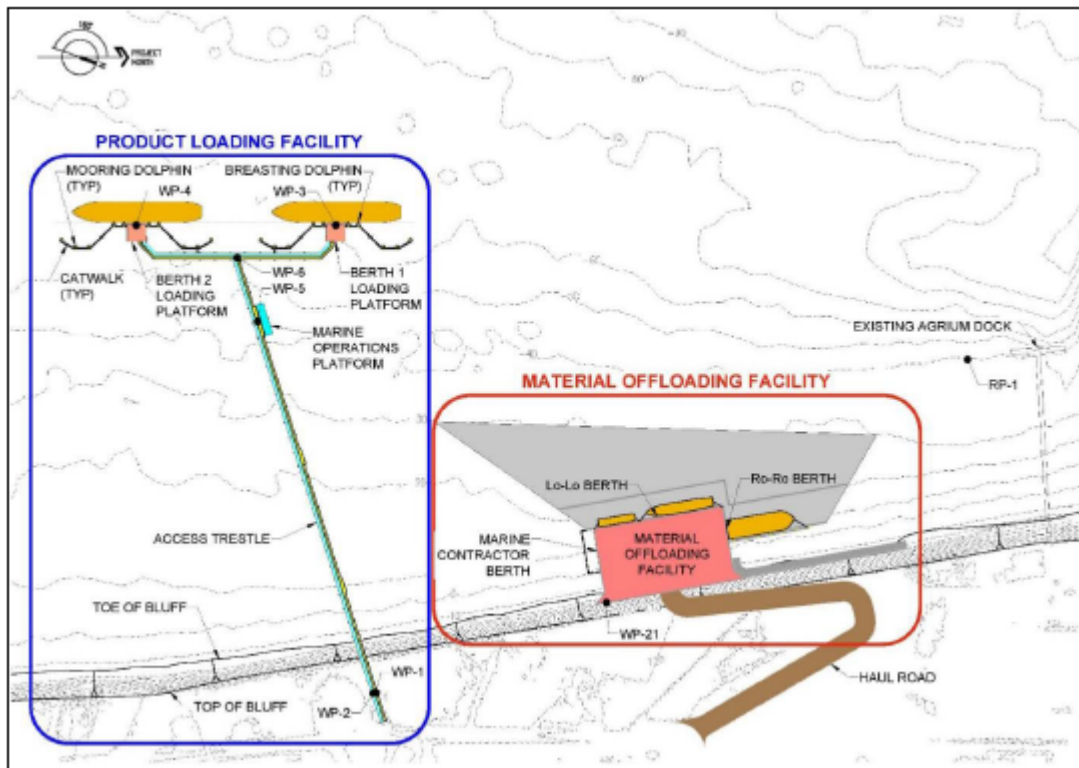


Figure 11. Product Loading Facility and Material Offloading Facility, near Nikiski (AGDC 2025)

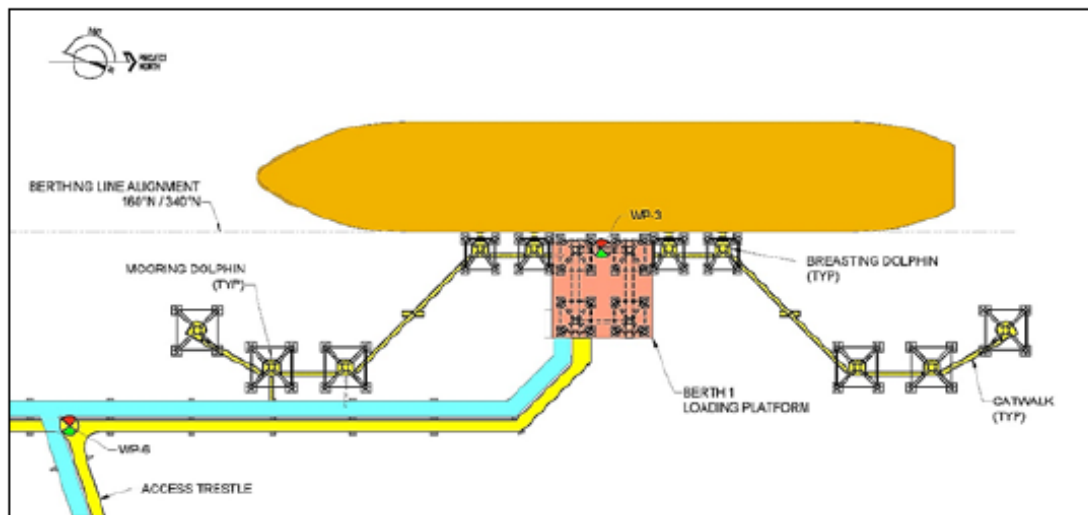


Figure 12. Berth layout at Product Loading Facility near Nikiski (AGDC 2025)

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.

Each season extends from April 1 through October 31, during which construction crews would be working 12 hours per day, 6 days per week.

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. ^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

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

^b 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.

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 (Figure 13), to be located near the PLF in Nikiski (Figure 11), will be a temporary facility consisting of two 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.

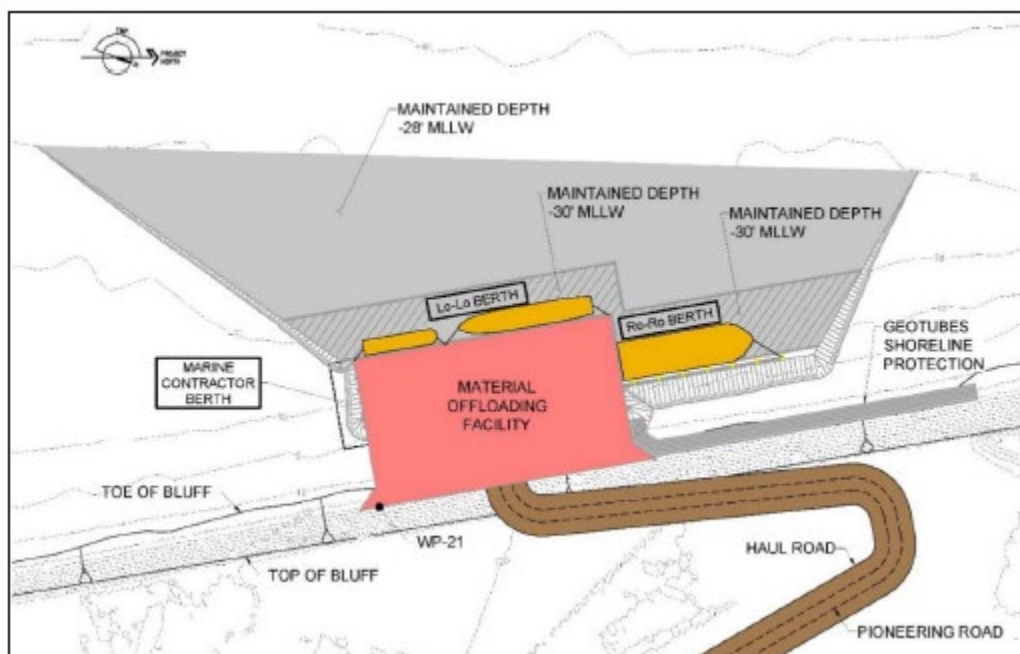


Figure 13. General arrangement of the temporary Material Offloading Facility, near Nikiski (AGDC 2025)

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 lift-on/lift-off (Lo-Lo) berth with a maintained depth alongside of -32 ft MLLW;
- One roll-on/roll-off (Ro-Ro) berth with a maintained depth alongside of -32 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. The construction of the sheet pile coffer cell wall will involve driving a set of 188 sheet piles per cell in a template to form a complete circle. Four, 24-inch bearing piles per template would be installed with a vibratory hammer before the sheet pile is installed for each coffer cell and then removed when coffer cell installation is complete. Once a cell is complete, it will be filled with granular material to provide mass before removing or relocating the template to the next cell. The remaining five coffer cells and fill would 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 / Sheets				Method	Hammer	Days ¹	Months
			24-inch	48-inch	66-inch	Sheet Pile				
1	Combi-wall ²	1	-	-	70	144	Land	Vibratory	22	Jul
1	Coffer cell	6	48 ³	-	-	1,496	Land	Vibratory	56	Jul-Oct
2	Coffer cell	5	40 ³	-	-	1,491	Land	Vibratory	54	Apr-Jun
2	Quadropod ⁴	7	7	28	-	-	Marine	Impact	14	Apr-Jun
All	-	19	95	28	70	3,131	-	-	146	Apr-Oct

¹ Number of days on which pile-driving would occur, based on expected progress rate of 2 days per structure for pile driving, 25 feet per day per crew for sheet pile and combi-wall. Pile driving would occur during only a portion of each of these days. One day is also required per structure for installation and removal of the templates for the coffer cell (see footnote 3).

² Combi-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 would 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.

³ These are 4 (temporary) 24-inch bearing 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 and removal for each coffer cell.

⁴ Each of these quadropods for the MOF Ro-Ro dolphins consists of five piles.

MOF Dredging

Dredging will be conducted over two ice free seasons (Years 2 and 3). 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 marine 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. Maintenance dredging may be conducted in Year 4 and/or Year 5.

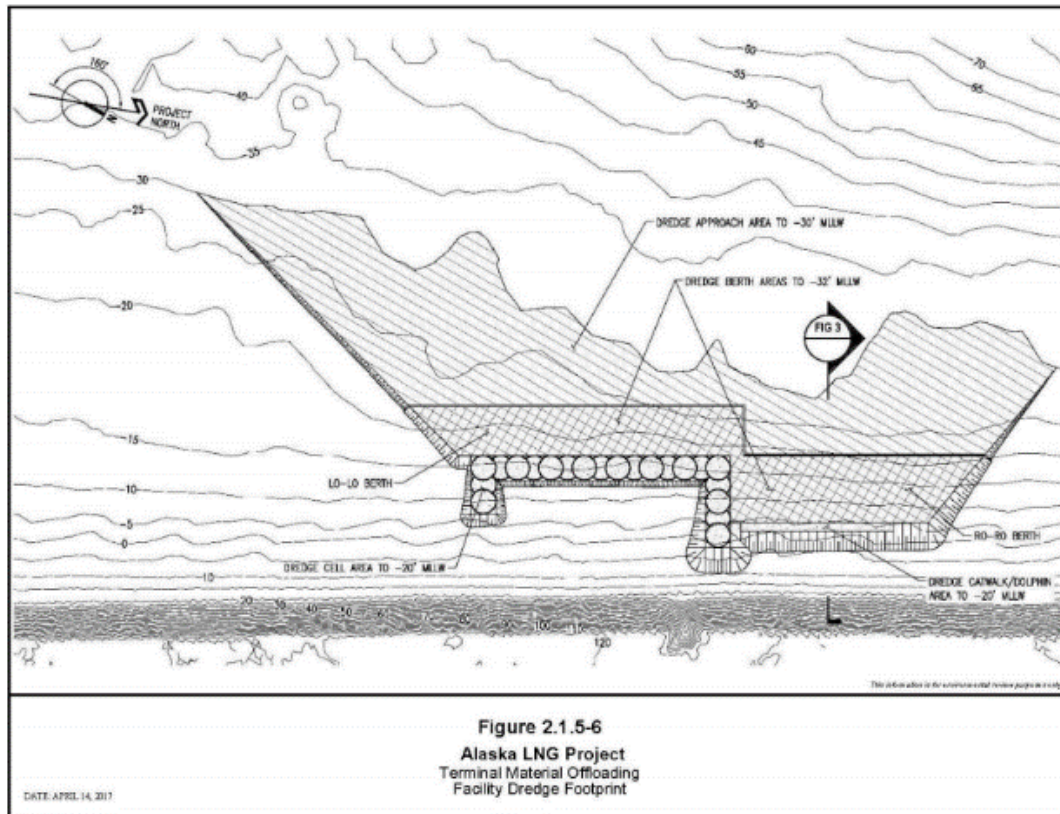


Figure 14. Dredging footprint of the Marine Terminal MOF near Nikiski

8 Star Alaska 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. 8 Star Alaska 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 for disposal. 8 Star Alaska 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).

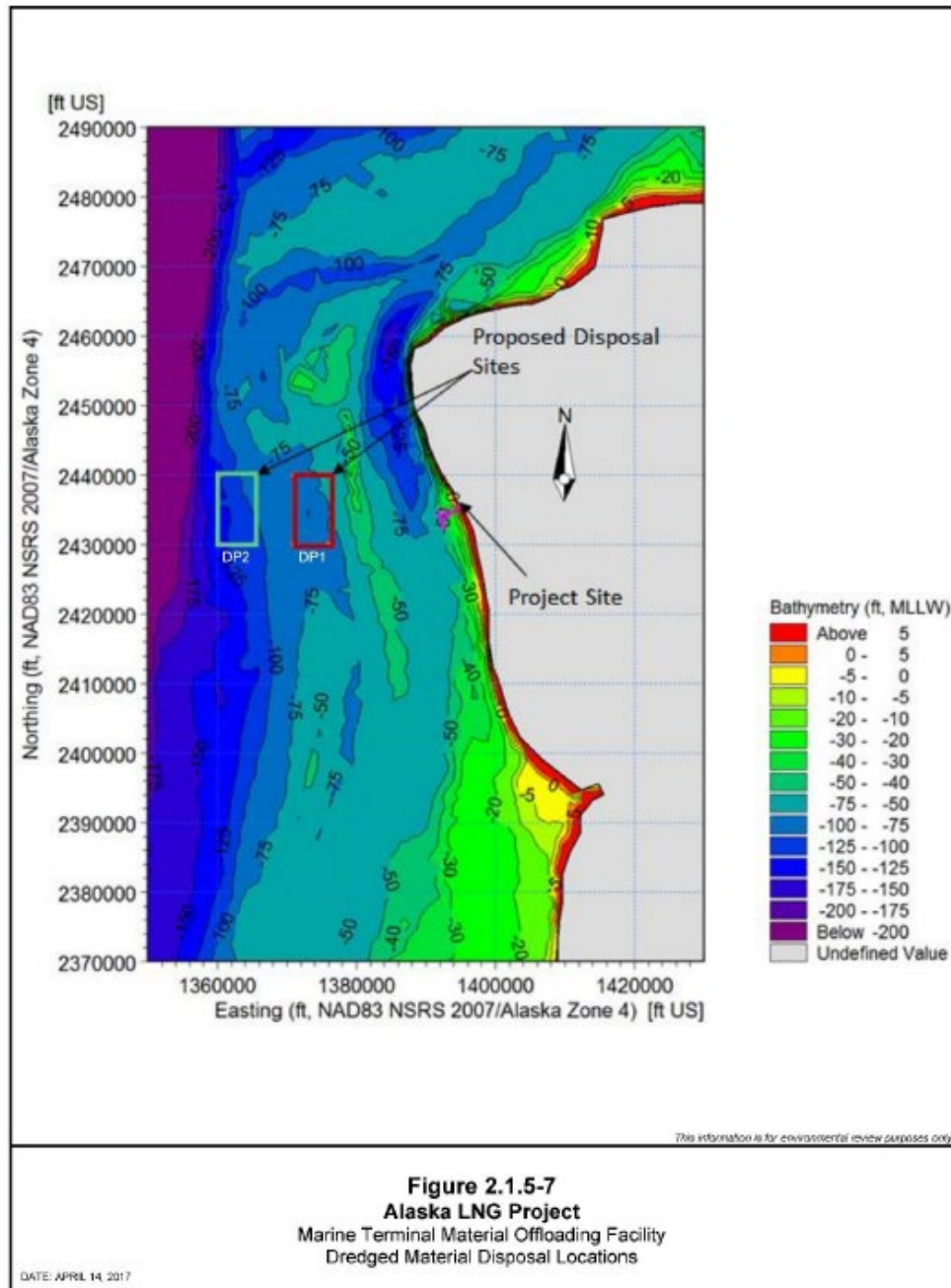


Figure 15. MOF dredging material disposal locations, near Nikiski

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; and
- associated infrastructure, including a condensate storage facility, catalysts and chemicals, lighting, communications facilities, and a consolidated building complex.

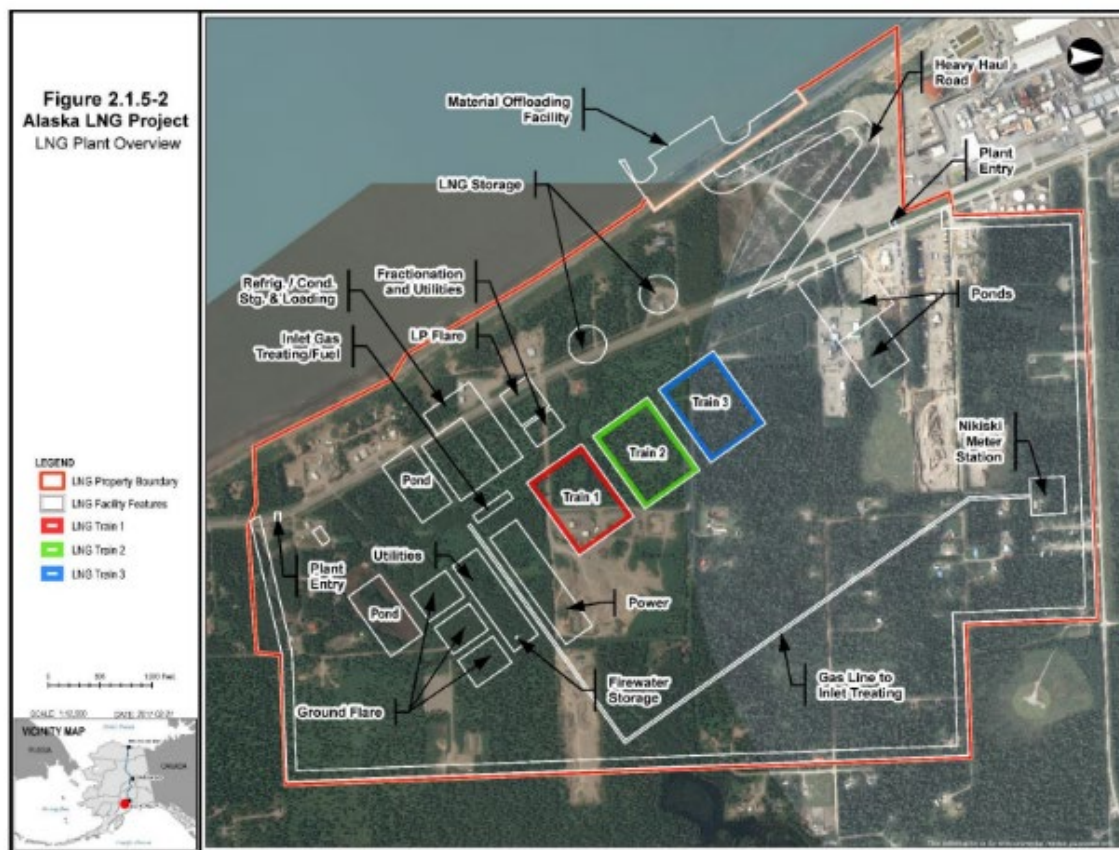


Figure 16. Overview of LNG Plant, near Nikiski

2.1.1.3 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. 8 Star Alaska 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 uses 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 oversize 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.

8 Star Alaska proposes to use the Port of Alaska (POA) and Port of 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. 8 Star Alaska 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. 8 Star Alaska 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.

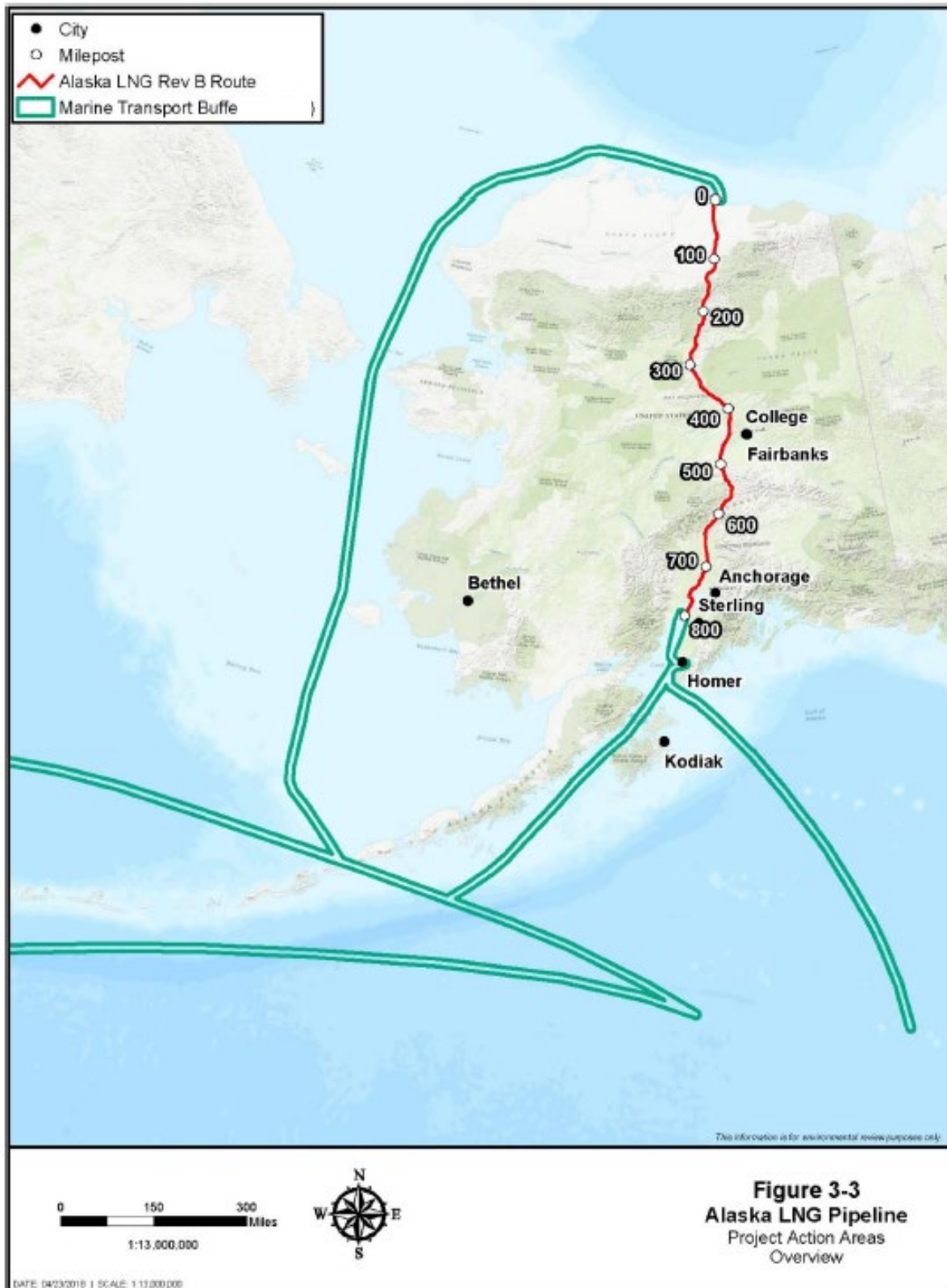


Figure 17. Marine traffic route for Alaska LNG project off Alaska

Table 21. Vessels associated with Prudhoe Bay construction (FERC 2020)

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)(FERC 2020)

	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
	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

	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				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
				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

	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
				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
		Year 5	Apr to May	Self-propelled RO-RO vessel - module carrier	17–21	5	5	5
	Cook Inlet Barge Traffic / Gulf of Alaska	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

	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			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
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

	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 Continued		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
				Tug & double hull barge (273,000 gallons)	9–21	6	1	6
		Year 3	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35
				Tug & double hull barge (273,000 gallons)	9–21	15	1	15
		Year 4	Apr to Oct	Tug & RO-RO ATB ramp barge (1,034 tons)	17–21	35	35	35
				Tug & double hull barge (273,000 gallons)	9–21	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
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	3	3
				Anchor hanging tug (shallow water)	12–16	1	2	2
				Dynamic Positioned survey vessel	10–26	1	1	1
				Pipe carrier (2,200-ton carrying capacity)	4–14	1	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
Port of Seward	Gulf of Alaska / North Pacific	Year 1	Year-round	Handymax self-propelled pipe carrier (18,000 tons)	11–15	1	11	11
		Year 2	Year-round	Handymax self-propelled pipe carrier (18,000 tons)	11–15	1	16	16
	Local	Year 1 – 3	Year-round	Assist tug for pipe vessels	11–15	1	3	3

^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).

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 that 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	Construction Year	Modules	Barges	Tugs		
				Ocean-going	Primary Assist ¹	Secondary Assist ¹
NEG2 ²	Year 1	8	9	9	2	6
NEG1 ²	Year 2	57	9	9	2	6
Sealift 1 ³	Year 3	17	12	12	2	6
Sealift 2 ³	Year 4	15	12	12	2	6
Sealift 3 ³	Year 5	10	10	10	2	6
Sealift 4 ³	Year 6	9	9	10	2	6
¹ Primary and secondary assist tugs remain in Prudhoe Bay area for the season, they are used to transit barges between PBOSA and DH4						
² Sealifts in NEG years are preconstruction sealifts transporting materials (smaller modules, equipment, and supplies)						
³ 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 limit 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)
* Variable depending on model					

Marine Transit Route - Operations

During the life of the project, vessel transit is anticipated to and from the Product Loading Facility in Cook Inlet, but no other vessel transits (such as to and from Prudhoe Bay) are anticipated. 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.

^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, 8 Star Alaska 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, 8 Star Alaska 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. 8 Star Alaska 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.

2.1.1.4 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 2.1.1.3 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. 8 Star Alaska 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

1. 8 Star Alaska will implement the following mitigation measures. 8 Star Alaska will notify NMFS 48 hours prior to the start of each activity in Cook Inlet covered in these mitigation measures. If there is a delay in activity, 8 Star Alaska will also notify NMFS as soon as practicable.

Time Restrictions

2. 8 Star Alaska will initiate DH4 construction activities prior to March 1, which is expected to discourage ringed seals from establishing lairs near these activities. Additionally, a subsistence advisor will survey areas within a buffer zone of DH4 where water depth is greater than 3 m to identify potential ringed seal structures before construction activity begins. Construction crews must avoid any identified seal structures by a minimum of 150 m.
3. 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).
4. Pile driving associated with the Mainline Material Offloading Facility (Mainline MOF) will occur only from September 8 – May 31.
5. Between April 15 and October 15, 8 Star Alaska would not conduct pile driving or anchor handling tugs (AHT) activities with Level B harassment isopleths that would extend shoreward of the MLLW line in the Susitna Delta (Beluga River to the Little Susitna River; see Figure 19) and project vessel(s) operating in or transiting through Cook Inlet would maintain a distance of at least 1.5 nautical miles seaward of the MLLW line in the Susitna Delta (Beluga River to the Little Susitna River).

Protected Species Observer (PSO) Protocols

6. PSOs will have the following knowledge, skills and abilities:
 - a. be in good physical condition and be able to withstand harsh weather conditions for an extended period of time;
 - b. 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;
 - e. identifying marine mammals in Alaskan waters to species based upon appearance or behavior; and
 - f. ability to classify marine mammal behavior types into pre-established categories.
7. PSOs will have training, orientation or experience with project operations sufficient to accurately report on activities occurring during marine mammal sightings.
8. 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; and
 - e. PSO roles and responsibilities.
9. 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.
10. PSOs will have the ability to effectively communicate in real time with project personnel to provide real-time information on marine mammals.
11. PSOs will have the ability and authority to order appropriate mitigation measures, including measures to avoid unauthorized takes of marine mammals.

12. 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. inclinometer;
 - 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; and
 - j. Observation Record forms printed on waterproof paper, or weatherproof electronic device allowing for required PSO data entry.
13. PSO will have no other primary duties beyond watching for, acting on, and reporting events related to marine mammals.
14. PSO will work in shifts lasting no longer than four hours with at least a one-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.
15. Prior to commencing in-water work or at changes in watch, PSOs should establish contact with the 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.
16. 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

17. 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. For all marine mammals except Cook Inlet beluga whales, the shutdown zone corresponds to the MMPA Level A zone. For Cook Inlet beluga whales, shutdown will occur whenever a

Cook Inlet beluga whale is observed anywhere within the MMPA Level B monitoring zone. When the shutdown zones (which are based on Level B zones) are larger than what PSOs can observe, the mitigation measures for Cook Inlet beluga whales apply to the furthest extent PSOs can observe but no less than 1000 m (which extends past the Level A zones to ensure no Level A take occurs). The radii for the Shutdown Zone for each of the project activities are summarized in Table 27 (Prudhoe Bay) and Table 28 (Cook Inlet). For Prudhoe Bay, 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). For Cook Inlet, for all marine mammals except Cook Inlet beluga whales, take will be recorded when animal(s) are observed within the shutdown and monitoring zones (Level B) (see Section 6 for the definitions of Level A and B harassment and how these zones were calculated). For Cook Inlet beluga whales, Level A take will be recorded when belugas enter within the calculated Level A zone (see Table 54), and Level B take will be recorded when belugas are seen in the monitoring zone or calculated based on a sampling plan for estimating Level B take (see Measure 18). 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).

18. 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 pinnipeds 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 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 these situations, 8 Star Alaska can undertake the following:

- a. Add PSO teams to fully observe the zone. This is typically the case when PSOs can be land based or positioned on stationary observation platforms.
- b. If additional PSO teams cannot be utilized to fully observe the zone, 8 Star Alaska can develop a sampling plan that is mutually agreed-upon by NMFS. Such a plan should include proportionate monitoring at all distances within the zone (such as a wedge of a circle), where that wedge includes at least 10 percent of the total zone (i.e., a 36 degree wedge). Sampling of the monitoring/shutdown zone will not occur until a mutually-agreed upon plan (by NMFS) is in place.

At all times, 8 Star Alaska must be able to monitor the entirety of the Level A zones for Prudhoe Bay (Table 27), the entirety of the shutdown zones for Cook Inlet for all species

except Cook Inlet beluga whales (Table 28), and for Cook Inlet beluga whales up to 1000 m. If these zones are not fully visible, activities must cease.

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	High Frequency Cetaceans	Phocids	
Impact of 11.5-in H-pile	1,200	150	500	350
Impact of 14-in H-pile	350	50	300	350
Impact of 48-in pile	750	100	500	2,150
Vibratory of 14-in H-pile	10	10	10	1,000
Vibratory of sheet piles	20	10	30	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 Shutdown Zones and Level B Monitoring Zones for Pile Driving in Cook Inlet

Activity	Shutdown Zone Radius (m)			Level B Monitoring Zone Radius (m)
	Low Frequency Cetaceans	Beluga Whales*	Otariids	All
Impact Pile Driving				
Sheet Pile at Mainline MOF	2,000	1,000	400	1,000
24-inch Pipe Pile at Marine Terminal MOF	1,000	1,000	350	1,000
48-inch Pipe Pile at PLF and Marine Terminal MOF	1,300	2,160	400	1,359
60-inch Steel Pipe Pile at PLF	2,000	2,160	400	2,154
Vibratory Pile Driving				
Sheet Pile at Mainline MOF and Marine Terminal MOF	30	4,642	20	4,642
24-inch Steel Pipe Pile at Marine Terminal MOF	20	7,356	10	7,356
66-inch Steel Pipe Pile at Marine Terminal MOF	60	21,544	30	21,544
66-inch Steel Pipe Pile x 2 at Marine Terminal MOF	90	34,146	40	34,146
66-inch Steel Pipe Pile with Sheet Pile at Marine Terminal MOF	150	21,544	70	21,544
Sheet Pile x 2 at Marine Terminal MOF	50	7,356	20	7,356
24-inch Steel Pipe Pile with Sheet Pile at Marine Terminal MOF	40	11,659	20	11,659
24-inch Steel Pipe Pile x 2 at Marine Terminal MOF	70	10,000	30	10,000

*When the shutdown zones for beluga whales (Level B) are larger than what PSOs can observe, pile driving would be shut down when beluga whales are visible within any distance, but no less than 1000 m. When the shutdown zones (which are based on Level B zones) are larger than what PSOs can observe, the zone must be fully visible up to 1000 m and the mitigation measures apply to the furthest extent PSOs can observe but no less than 1000 m (which extends past the Level A zones to ensure no Level A take occurs).

19. If a marine mammal(s) is likely to enter the shutdown zone, 8 Star Alaska will shut down activities prior to the animal entering the shutdown zone.
20. Shutdown will be initiated at the PSO's direction when warranted due to the presence of marine mammals.
21. 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. This measure applies to all shutdown zones in Table 27 and Table 28. For Cook Inlet beluga whales, when the shutdown zones (which are based on Level B zones) are larger than what PSOs can observe, these mitigation requirements outlined in this measure apply to the furthest extent PSOs can observe but no less than 1000 m (which extends past the Level A zones to ensure no Level A take occurs).

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. For Cook Inlet beluga whales, when the shutdown zones are larger than what PSOs can observe, this mitigation requirement applies to the furthest extent PSOs can observe but no less than 1000 m.
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, PSOs 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, 8 Star Alaska 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 8 Star Alaska needs to perform 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. For Cook Inlet beluga whales, when the shutdown zones are larger than what PSOs can observe, this mitigation requirement applies to the furthest extent PSOs can observe but no less than 1000 m.
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

31. Prior to anchor handling, 8 Star Alaska will implement clearance zones that will be monitored for a sufficient time to ensure marine mammals are not present in this zone before starting. 8 Star Alaska would implement a clearance zone of 1,500 m around AHTs for all marine mammals other than Cook Inlet beluga whales (CIBWs). The clearance zone for beluga whales would be equal to the Level B harassment isopleth (3,850 m). If PSOs cannot observe the entirety of the clearance zone for beluga whales, PSOs would be expected to clear the zone around AHTs at the distance visible to PSOs. For Cook Inlet beluga whales, this mitigation requirement applies to the furthest extent PSOs can observe but no less than 1000 m. Any instance of a marine mammal within the

Level A zone for this activity must be reported consistent with reporting unauthorized take (Mitigation measure 64).

32. If anchor handling/dynamic positioning is in progress when marine mammals enter this clearance 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

33. PSOs will be on-watch daily during daylight hours for the duration of the pipelaying/trenching activities.
34. PSOs will be stationed on the pipelay vessel and/or on an elevated platform on land.
35. 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 a zone of 3,850 m for belugas, and 1,500 m for all other marine mammals, has been cleared. If PSOs cannot observe the entirety of the clearance zone for beluga whales, PSOs would be expected to clear the zone around AHTs at the distance visible to PSOs. For Cook Inlet beluga whales, this mitigation requirement applies to the furthest extent PSOs can observe but no less than 1000 m. Any instance of a marine mammal within the Level A zone for this activity must be reported consistent with reporting unauthorized take (Mitigation measure 64).
36. 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

37. 8 Star Alaska 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 while dredging and screeding. These pilots will enforce the shutdown zone of 215 m for all vessels when engaged in dredging and screeding.

Ice Trenching

38. 8 Star Alaska will require that operators of ice trenching equipment used for seafloor preparation will have clear views of the monitoring zones to facilitate effective observations for all protected species while trenching. These operators will enforce the shutdown zone of 40 m for all ice trenching activities.

Fill Placement

39. 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.

40. 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.

Vessels

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.

41. To protect against water quality degradation in Cook Inlet and Prudhoe Bay during project construction and operation and to reduce the risk of aquatic invasive species from vessel traffic, 8 Star Alaska will implement, or require vessel operators to implement, the following plans:
 - a. Invasive Species Plan; and
 - b. Ballast Water Management Plan.

Under these plans, heavy lift vessels will ballast loads with cargo rather than water and use minimal amounts of freshwater for ballast. There will 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). 8 Star Alaska also will require visiting vessels to possess documentation to demonstrate compliance with ballast water best management practices prior to allowing ballast water to be discharged into the berthing area. The Ballast Water Management Plan will include protocols and management measures for LNG carriers and ships transporting equipment.

42. The transit of operational and support vessels through the North Slope region is not authorized January 1 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.

43. The transit route for the vessels will: minimize transit in known biologically important areas (see Figures in this opinion showing biologically important areas or BIAs) (Ferguson et al 2015a,b; Clarke et al. 2015), and avoid designated critical habitat, to the extent practicable.
44. 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.
45. Vessel operators will maintain a vigilant watch for marine mammals to avoid disturbance and vessel strikes.
46. 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.
47. 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).
48. 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).
49. Vessels should take reasonable steps to alert other project vessels in the vicinity of whale presence.
50. 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.
51. The 8 Star Alaska will ensure that measures to minimize risk of spilling hazardous substances are implemented.

52. Relative to designated North Pacific right whale critical habitat, project watercraft will:
- avoid transiting through designated North Pacific right whale critical habitat (73 FR 19000);
 - 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
 - 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.
 - The PSO will record the time and geographic coordinates at which vessels enter and exit North Pacific right whale critical habitat.
53. Vessels will not approach within 5.5 kilometers (3 nautical miles) of rookery sites listed in 50 CFR § 224.103(d) and the rookeries and haulouts listed at Tables 1 and 2 to 50 CFR part 226.
54. 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 16 km (10-mile) buffer of the Beluga River thalweg seaward of the MLLW line;
 - a 16 km (10-mile) buffer of the Little Susitna River thalweg seaward of the MLLW line; and,
 - a 16 km (10-mile) seaward buffer of the MLLW line between the Beluga River and Little Susitna River.
 - 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:

- 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.
- 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.
55. 8 Star Alaska 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 8 Star Alaska and NMFS AKR (Table 63) 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.

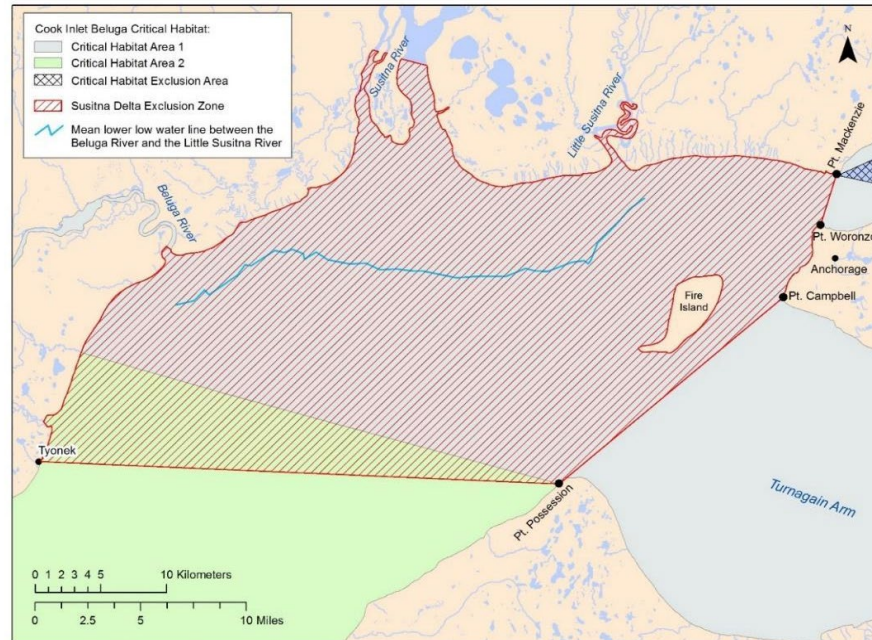


Figure 18. Susitna Delta Exclusion Zone, showing MLLW line between the Beluga and Little Susitna rivers

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.

56. 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.
57. Aircraft will keep a distance of at least 1.6 km (1 mi) from Steller sea lion rookery sites listed in 50 CFR § 224.103(d) and rookeries and haulouts listed at Tables 1 and 2 to 50 CFR part 226.

Other Mitigation Measures

58. 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.

59. 8 Star Alaska will be responsible for implementing plans, or requiring contractors or other vessel operators/carriers to implement such plans, to address mitigate impacts and address effects associated with the project, such as authorized and unauthorized discharges of petroleum products and other pollutants into the environment, including:
- Project Spill Prevention, Control, and Countermeasure Plan, which will include fueling, storage, containment, and cleanup measures, as well as preventative measures, to minimize the potential for releases of petroleum products and other pollutants into the marine environment;
 - Shipboard Oil Pollution Emergency Plan, to require LNG carriers to develop and implement measures to be taken when an oil pollution incident has occurred or a ship is at risk of one;
 - Stormwater Pollution Prevention Plan; and
 - Project Wetland and Waterbody Construction and Mitigation Procedures.

8 Star Alaska will develop facility/work site-specific Project Spill Prevention, Control, and Countermeasure (SPCC) Plans prior to construction, and contractors will be required to develop their own site-specific Plans that would be subject to project review and approval. Measures outlined in the Project SPCC Plans and Project Wetland and Waterbody Construction and Mitigation Procedures will be implemented during construction to include measures such as secondary containment, setbacks, daily maintenance and inspection of construction equipment for leaks. Additionally, Project SPCC Plans and Project Wetland and Waterbody Construction and Mitigation Procedures will 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.

Data Collection

60. 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).
61. PSO will use a NMFS-approved Observation Record. Observation Records will be used to record the following:
- date and time that activity and observation efforts begin and end;
 - 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>);
 - 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;
 - 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; and
- 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

- 62. All reports submitted to NMFS Permits Division will also be simultaneously submitted to NMFS AKR.
- 63. **Exceedance of Authorized Take** - 8 Star Alaska 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. 8 Star Alaska will immediately notify NMFS AKR (see Table 29 for contact information) if the number of takes documented exceeds the authorized takes in any given calendar year during which take is authorized.
- 64. **Unauthorized Take** - In the event that personnel involved in the construction activities discover an injured or dead marine mammal, 8 Star Alaska will report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS AKR, 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, 8 Star Alaska 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 and conditions of the Biological Opinion's Incidental Take Statement and terms of the IHA or LOA. 8 Star Alaska 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).

65. **Vessel Strike** - Though take of marine mammals by vessel strike is not authorized, if a listed marine mammal is struck by a vessel, it must be reported to NMFS AKR (see Table 29 for contact information) within 24 hrs. See mitigation measure 61 for information that will be submitted, as applicable following a vessel striking a marine mammal.

66. **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

67. Monthly reports will be submitted by 8 Star Alaska 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; and
- 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

68. Within 90 calendar days of the cessation of in-water work each year, a comprehensive annual report will be submitted by 8 Star Alaska 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 8 Star Alaska 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 mitigation measure 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; and
- g. analyses of the effects of project activities on listed marine mammals

Final Report

69. In addition to providing NMFS monthly and annual reporting of marine mammal observations and other parameters described above, 8 Star Alaska 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 8 Star Alaska 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
Consultation Questions & Unauthorized Take	akr.prd.section7@noaa.gov
Reports & Data Submittal	akr.prd.records@noaa.gov
Stranded, Injured, or Dead Marine Mammals	Stranding Hotline (24/7 coverage) 1-877-925-7773
Oil Spill & Hazardous Materials Response	U.S. Coast Guard National Response Center: 1-800-424-8802 and AKRNMFSResponse@noaa.gov
Illegal Activities (<i>not related to project activities; e.g., feeding, unauthorized harassment, or disturbance to marine mammals</i>)	NMFS Office of Law Enforcement (AK Hotline): 1-800-853-1964
In the event that this contact information becomes obsolete	NMFS Anchorage Main Office: 907-271-5006 or NMFS Juneau Main Office: 901-206-4342

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 also 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 portion of the action area, the loudest underwater sound source with the greatest propagation distance is anticipated to be vibratory pile driving of 25-in steel piles. Within the Cook Inlet portion, the loudest underwater sound source with the greatest propagation distance is anticipated to be concurrent vibratory pile driving of two 66-inch sheet piles. These distances are shown as the Level B zones in Table 27 and Table 28.

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 routes that vessels will take when transiting from Dutch Harbor to Prudhoe Bay; the routes vessels will take transiting to and from ports in the lower 48, though the Gulf of Alaska, to ports in and around the construction sites in Cook Inlet; and the routes 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. 1995a).

However, if 8 Star Alaska, 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 6.3.1.1).

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 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 designation(s) of critical habitat use different terms, such as primary constituent element (PCE) or essential features, for the “physical or biological features” identified for each designated critical habitat. The 2016 critical habitat regulations (81 FR 7414; February 11, 2016) replaced these terms 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, our use of the term PBF also applies to Primary Constituent Elements and essential features.

We use the following approach to determine whether the proposed action described in Section 2 of this opinion is likely to jeopardize listed species:

- Identify those aspects (or stressors) of the proposed action that are likely to have effects on listed species. 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 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. Species status is 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 sex of the individuals that are likely to be exposed to stressors and the populations or subpopulations those individuals represent. 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 listed species. 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 appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. These assessments are made in full consideration of the status of the species (Section 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.
- Reach jeopardy conclusions. Conclusions regarding jeopardy 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, NMFS must identify a reasonable and prudent alternative (RPA) to the action.

For all analyses, we use the best available scientific and commercial data. For this consultation, this includes the following:

- FERC’s EIS, including Appendix O – Biological Assessment
- Proposed Rule: Cook Inlet LOA (90 FR 35762, July 20, 2025)
- 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 and concurrence consider 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 and concurrence.

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

Species	Status	Listing	Critical Habitat
Humpback whale, Mexico DPS (<i>Megaptera novaeangliae</i>)	Threatened	NMFS 2016 , 81 FR 62260	NMFS 2021, 86 FR 21082
Humpback whale, Western North Pacific DPS (<i>Megaptera novaeangliae</i>)	Endangered	NMFS 2016 , 81 FR 62260	NMFS 2021, 86 FR 21082
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	NMFS 2022, 87 FR 19232 ³
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	Threatened	NMFS 2012, 77 FR 76740	NMFS 2022, 87 FR 19180 ³
Steller sea lion, Western DPS (<i>Eumetopias jubatus</i>)	Endangered	NMFS 1997, 62 FR 24345	NMFS 1993, 58 FR 45269
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

³ See footnote 1 above.

Species	Status	Listing	Critical Habitat
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

NMFS uses two criteria to identify those endangered or threatened species or critical habitats that are likely to be adversely affected by the agency action. The first criterion is exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with the proposed action and a listed species or designated critical habitat. The second criterion is an assessment of the potential response given exposure. If all potential stressors are extremely unlikely, insignificant, or beneficial in their effects to a listed species or designated critical habitat, the action is not likely to adversely affect that species or critical habitat.

We applied these criteria to the species and critical habitats listed above in Table 30 and determined that the proposed action is not likely to adversely affect the following species and designated critical habitats: blue whale, North Pacific right whale and its critical habitat, sei whale, Western North Pacific DPS gray whale, Steller sea lion critical habitat, Cook Inlet beluga whale critical habitat, Mexico DPS humpback whale critical habitat, Western North Pacific DPS humpback whale critical habitat, Beringia DPS bearded seal critical habitat, and Arctic ringed seal critical habitat. Below we discuss our rationale for those determinations.

In addition, the action agencies determined that the action would have no effect on designated critical habitat for listed salmonids (Chinook salmon ESUs and steelhead DPSs listed above). The entire portions of the action area in Prudhoe Bay and Cook Inlet and the majority of the marine transit route do not overlap with designated critical habitat for listed salmonids. The only portion of the action area that could overlap with designated critical habitat for listed salmonids is a small portion of the marine transit route if any project-specific vessels originated from the lower 48.

4.1.1 Blue Whale, North Pacific Right Whale, Sei Whale, and Western North Pacific DPS Gray Whale

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 (GOA), and the Marine Terminal in Nikiski overlap with the ranges of the blue whale, North Pacific right whale, sei whale, and Western North Pacific gray whale. 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 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, based on an analysis of Automated Identification System (AIS) data for the 8-year period 2017–2024, there were 3,862 vessel transits⁴ through the Bering Strait, with an 85 percent increase in the number of yearly transits between 2017 and 2024 (Marine Exchange of Alaska 2024). 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 small in comparison to the existing level of vessel traffic in this portion of the action area, which has also been increasing over time.

During the 4-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 specifically, 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 2015), 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.

Based on AIS data, 2,252 unique tankers and cargo vessels >400 gross tons completed a total of 8,794 transits through the North Pacific Great Circle Route between 2014 and 2017, the majority of which were cargo vessels and transits (94 and 96 percent, respectively) (Sullender et al. 2021).

⁴ North bound and south bound transits; limited to one northbound and one southbound transit by a unique vessel per day.

Most of these transits (89 percent) crossed through Unimak Pass. Many additional vessels not included in the AIS data 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 Marine Exchange of Alaska (2024), transits from project vessels would account for an approximately 4.6 to 8.2 percent increase in the number of vessel transits per year.

8 Star Alaska 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. 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. 8 Star Alaska 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, 8 Star Alaska 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. 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, or Western North Pacific gray whales 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, and such effects are, therefore, insignificant.

Vessels transiting the marine environment also have the potential to collide with, or strike, marine mammals (Laist et al. 2001; Jensen and Silber 2003; Gende et al. 2019). For example, from 1978 to 2012, there were at least 108 recorded whale-vessel collisions in Alaska, with the majority occurring in Southeast Alaska (Neilson et al. 2012a). According to Neilson et al. (2012a), 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 for 0.9 percent, and sperm whales for 0.9 percent. Twenty-eight large whale-vessel strikes were reported between 2018 and 2022 in Alaska: 23 humpback whales, 2 fin whales, 1 sperm whale, and 2 unidentified whales (Brower et al. 2024b).

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).

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 one reported vessel strike (Table 62) of gray whales. 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. There are approximately 271 individuals in the gray whale Western North Pacific DPS (listed under the ESA) and 25,849 individuals in the Eastern North Pacific stock (not listed under the ESA) (Carretta et al. 2024). 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 (45–80 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 one percent of possible gray whales that could encounter vessels associated with the proposed action. Given that vessel strikes of gray whales are rare and nearly all gray whales in the waters off Alaska are from the unlisted Eastern North Pacific stock, NMFS concludes that it is extremely unlikely that a vessel associated with the proposed action will strike an ESA-listed Western North Pacific DPS gray whale.

Based on the transitory nature of project-related vessel traffic, mitigation measures in place to minimize or avoid effects of transiting vessels on marine mammals, and decades of vessels transiting in the Bering and Chukchi seas, the GOA, and the North Pacific with only two reports of a vessel strike on these species in Alaska, NMFS concludes that a vessel associated with the

project striking a blue whale, North Pacific right whale, sei whale, or Western North Pacific gray whale is extremely unlikely to occur.

4.1.1.2 Pile Driving and Dredging

Construction of the proposed facilities in Cook Inlet includes pile driving and dredging, which can result in acoustic and behavioral effects on marine mammals. However, 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 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. Therefore, NMFS concludes that adverse effects to blue whales, North Pacific right whales, Western North Pacific gray whales, or sei whales from pile driving or dredging are extremely unlikely to occur.

Pile driving and dredging activities will also occur in Prudhoe Bay. The whales discussed in this section do not have ranges that overlap with the action area within Prudhoe Bay. Therefore, the effects of pile driving and dredging activities within Prudhoe Bay would have no effect on the whales included in this section.

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, or Western North Pacific DPS gray whales. 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.

8 Star Alaska 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, which would reduce the likelihood of spills and the magnitude of spills should they occur (see Section 6.4.9 for more details). Further, in the event of a small spill, dispersal and evaporation of fuels and other pollutants are expected to occur quickly due to wind and tidal currents (as discussed in Section 6.4.9, spills of larger volume are not reasonably likely to occur). The listed cetaceans are also likely to be widely distributed and not in close proximity to the spill source (transiting vessels). Thus, NMFS concludes that exposure to fuels and other pollutants is extremely unlikely to occur. If exposure does occur, NMFS concludes that any impact of an accidental small spill associated with the proposed action will be very minor and effects to blue whales, North Pacific right whales, sei whales, or Western North Pacific DPS gray whales will be immeasurably small and thus insignificant.

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. This mitigation measure also prohibits tow lines to remain in the water. 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, given the mitigation measures in place, 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 extremely unlikely that any of these species will be adversely affected by marine debris associated with the proposed action.

In summary, for the reasons stated above, we conclude that any effects of the proposed action on the blue whale, North Pacific right whale, sei whale, and Western North Pacific DPS gray whale will be immeasurably small and therefore insignificant or extremely unlikely to occur, and therefore we concur that this action is not likely to adversely affect these species.

4.1.2 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 population groups of salmon and steelhead, including: overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. Salmon and steelhead from the listed ESUs/DPSs 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.

NMFS (2016a) described the early ocean migration patterns of Pacific Northwest salmonids as follows. In general, spring Chinook salmon move rapidly north in varying distances along the continental shelf, as far north as Alaska; fall Chinook remain in local waters (Myers et al. 1996; Burke et al. 2013; Fisher et al. 2014; Hayes and Kocik 2014). Steelhead generally exhibit a unique marine migration pattern and move directly offshore and apparently west across the North Pacific Ocean (Myers et al. 1996; Daly et al. 2014). 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 5-year status reviews, the listing determinations, and recovery plans for these ESUs/DPSs. Although the presence of listed salmonids in Alaskan waters has been documented in a number of fisheries and research surveys (Crane et al. 2000; Templin and Seeb 2004; Morris et al. 2007; Tucker et al. 2012; Beacham et al. 2014; Fisher et al. 2014; Tucker et al. 2015), available information suggests that they comprise a small percentage of the salmon and steelhead that occur within the action area, particularly in Cook Inlet. NMFS does not anticipate any overlap in the distribution of listed salmon and steelhead and the portion of the action area in Prudhoe Bay.

Potential stressors to ESA-listed salmonids caused by the proposed action include increased turbidity, elevation in noise levels, and pollutants. The proposed action has the potential to increase turbidity during pile installation, dredging and disposal, and nearshore and offshore pipeline trenching laying for pipeline installation across Cook Inlet. As described above and in

Section 6.4.5 (*Seafloor Disturbance and Habitat Alteration*), pile installation may temporarily increase turbidity resulting from suspended sediments. 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. We conclude that any increases in turbidity would be temporary, localized, and have no measurable impact on these species. Further, the probability of these species being exposed such turbidity is very low and thus adverse effects to ESA-listed salmonids are extremely unlikely to occur.

Although accidental spills or releases of petroleum products and natural gas leaks have the potential to affect ESA-listed salmonids, the preventive measures included in the mitigation measures would reduce the likelihood of spills and the magnitude of spills should they occur (see also Section 6.4.9). Further, in the event of a small spill occurring, dispersal and evaporation of fuels and other pollutants are expected to occur quickly due to wind and currents. The only potentially harmful effect to ESA-listed salmonids from a natural gas leak would be due to depletion of oxygen from a plume of water downstream from the release site, an effect that fish will be able to avoid given their mobility. In addition, extreme tidal mixing will greatly reduce the size of the hypoxic plume. For these reasons, we expect adverse effects to ESA-listed salmonids from pollutants and contaminants will be immeasurably small, and thus insignificant.

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 extremely 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 POA 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 over 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. In all, the best available data indicate that effects from pile driving and construction activities in Cook Inlet would be immeasurably small and extremely unlikely to occur.

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

4.1.3 Critical Habitat for the North Pacific Right Whale, Steller Sea Lion, Cook Inlet Beluga Whale, Mexico DPS Humpback Whale, Western North Pacific DPS Humpback Whale, Beringia DPS Bearded Seal, and Arctic Ringed Seal

4.1.3.1 North Pacific Right Whale Critical Habitat

NMFS issued a final rule designating critical habitat for the North Pacific right whale on April 8, 2008 (73 FR 19000; Figure 19). The PBFs associated with the critical habitat identified as essential to the conservation of the North Pacific right whale (also known as primary constituent elements, or PCEs) are the copepods *Calanus marshallae*, *Neocalanus cristatus*, and *N. plumchris*, and the euphausiid *Thysanoessa raschii*, in areas of the North Pacific Ocean in which North Pacific right whales are known or believed to feed (50 CFR 226.215). It is likely that certain physical forcing mechanisms are present in these areas and act to concentrate the identified prey species in densities that allow for efficient foraging by right whales (73 FR 19000, April 8, 2008).

On March 10, 2022, NMFS received a petition from the Center for Biological Diversity and Save the North Pacific Right Whale requesting revision to the critical habitat designation for the North Pacific right whale. We published a positive 90-day finding on July 12, 2022, stating the petition presented substantial scientific information indicating that the petitioned action may be warranted (87 FR 41271, July 12, 2022). After conducting a review of currently designated critical habitat and soliciting public comment to inform the review process, we published a 12-month finding indicating that a revision of critical habitat is warranted and described our approach for developing a proposed rule for public comment (88 FR 65940; September 26, 2023). This process is currently ongoing.

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), and related effects from exposure to spilled or otherwise-discharged fuel or other chemicals, acoustic disturbance, and impacts to prey. The portions of the action area associated with construction in Cook Inlet and Prudhoe Bay do not overlap with any North Pacific right whale critical habitat. While vessels associated with the action may enter designated critical habitat, vessel traffic is not expected 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, and the use of the Shelikof Strait for transit into and out of Cook Inlet, 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 PBFs of 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 the PBFs would be immeasurably small. We also do not expect that noise from transiting project vessels would result in effects on the PBFs 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. We therefore concur that the proposed action is not likely to adversely affect critical habitat for the North Pacific right whale.



Figure 19. North Pacific right whale critical habitat.

4.1.3.2 Steller Sea Lion Critical Habitat

NMFS published a final rule designating critical habitat for Steller sea lions on August 27, 1993 (58 FR 45269). In Alaska, designated critical habitat includes the following areas described at 50 CFR 226.202:

1. Terrestrial zones that extend 3,000 ft (0.9 km) landward from each major haulout and major rookery in Alaska.
2. Air zones that extend that extend 3,000 ft (0.9 km) above the terrestrial zone of each major haulout and major rookery.
3. Aquatic zones that extend 3,000 ft (0.9 km) seaward of each major haulout and major rookery that is east of 144°W. longitude.
4. Aquatic zones that extend 20 nm (37 km) seaward of each major haulout and major rookery that is west of 144°W. longitude.
5. Three special aquatic foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area, as specified at 50 CFR 226.202(c).

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 20). 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 20). The furthest north location of designated critical habitat (along the marine transit route between Dutch Harbor and Prudhoe Bay) is St. Lawrence Island, and the portion of the action area associated with construction in Prudhoe Bay does not overlap with any Steller sea lion critical habitat. The portion of the action area associated with construction in Cook Inlet also does not overlap with any Steller sea lion critical habitat (the construction locations in Cook Inlet are at least 200 km from critical habitat).

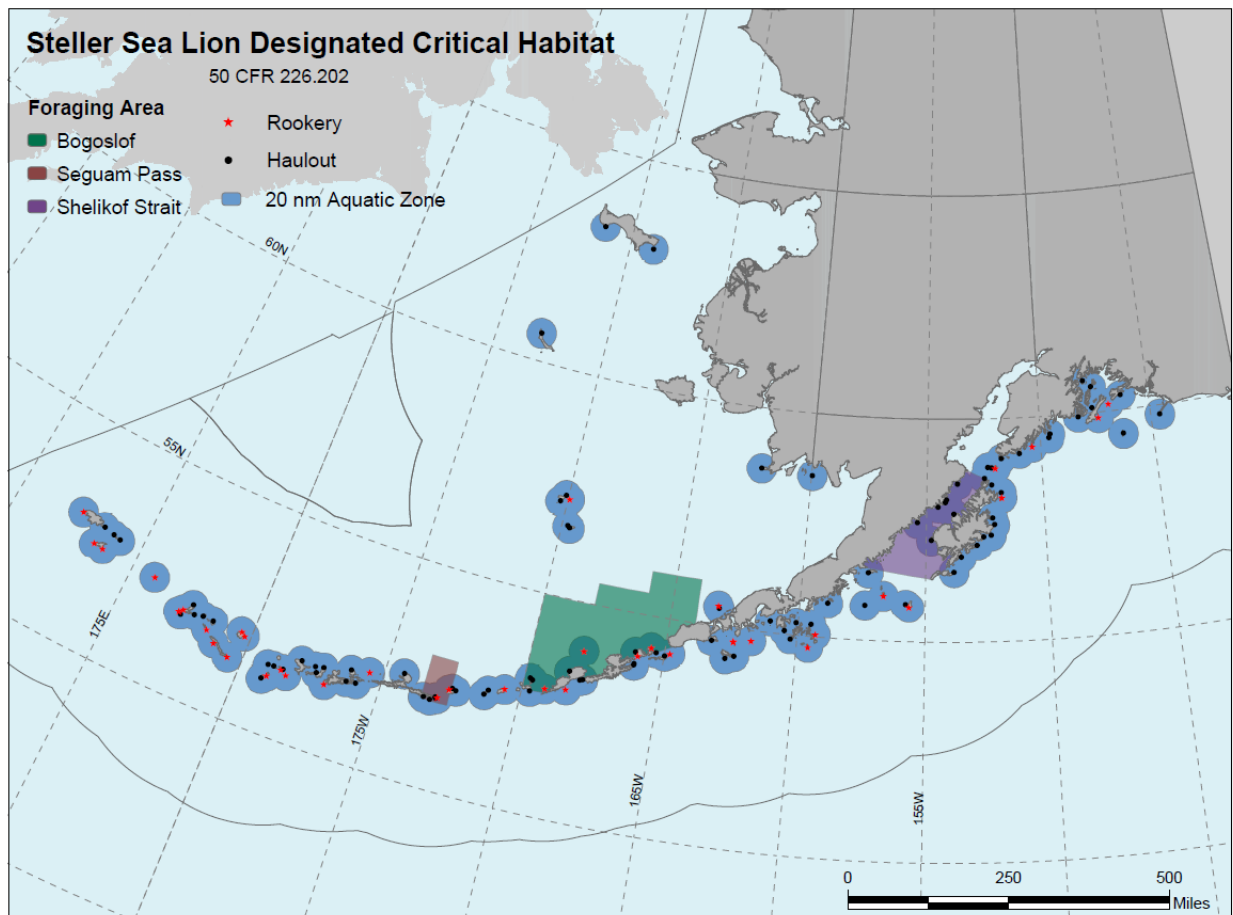


Figure 20. Designated Steller sea lion critical habitat west of 144°W longitude.

The potential effects of the action that may overlap with Steller sea lion critical habitat include effects from vessels transiting between Dutch Harbor and Prudhoe Bay and to and from the Marine Terminal in Cook Inlet (Nikiski) (acoustic disturbance, impacts to prey) and exposure to spilled or otherwise-discharged fuel or other chemicals.

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-nm (5.5-km) no transit buffers established around Steller sea lion rookeries in the Aleutian Islands and GOA identified at 50 CFR 224.103(d)(1)(iii) provide further protection. 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 expected to have adverse effects on Steller sea lion prey that occur in these areas or impact Steller sea lion 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.

Spills or otherwise-discharged fuels may occur in Steller sea lion critical habitat during project-related vessel transit. In the unlikely event of a small spill, dispersal and evaporation of fuels and other pollutants are expected to occur quickly due to wind and tidal currents. In addition, given that 8 Star Alaska will be implementing mitigation measures so that project vessels avoid approaching within 3 nm (5.5 km) of major Steller sea lion rookeries and haulouts, if a small spill from a vessel occurs that results in released contaminants reaching the shore of a major haulout or a major rookery, any effects on the terrestrial zones would be highly localized and transient.

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 small spill, dispersal and evaporation are expected to occur before discharged materials reach Steller sea lion critical habitat.

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 will be immeasurably small. We therefore concur that the proposed action is not likely to adversely affect critical habitat for the Steller sea lion.

4.1.3.3 Cook Inlet Beluga Whale Critical Habitat

NMFS published the final rule designating critical habitat for the Cook Inlet beluga whale on April 11, 2011 (76 FR 20180). Critical habitat includes two areas (referred to as Area 1 and Area 2) that generally describe summer (Area 1) versus winter (Area 2) habitat (Figure 21). The following PBFs associated with Cook Inlet beluga whale critical habitat were identified as essential to the conservation of the species (50 CFR 226.220):

1. intertidal and subtidal waters of Cook Inlet with depths less than 30 ft (mean lower low water (MLLW)) and within 5 mi 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; and
5. waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales.

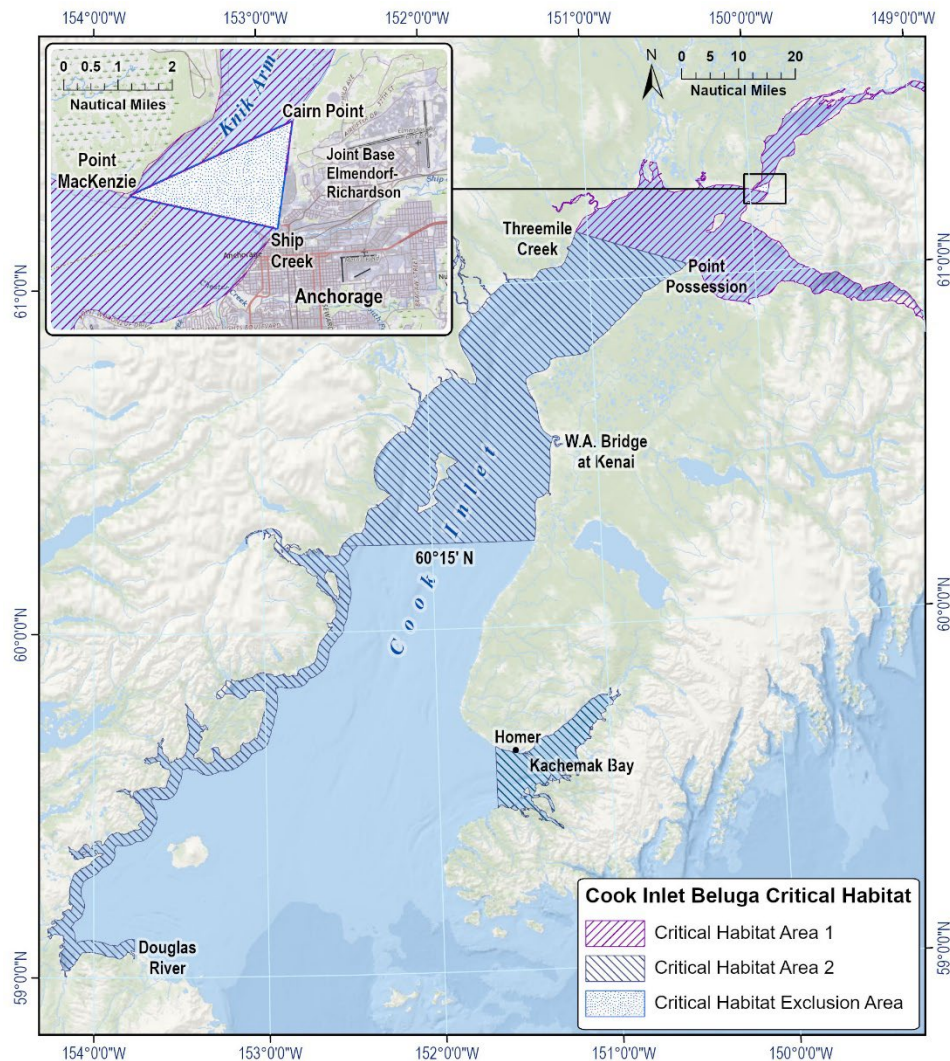


Figure 21. Designated Cook Inlet beluga whale critical habitat.

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 21). The Mainline MOF and the Mainline entrance into Cook Inlet will occur far enough south of the boundary between critical habitat Areas 1 and 2 (Figure 21 and Figure 22) such that noise from pile driving capable of causing take

of beluga whales is not expected to extend into Area 1. These proposed facilities are approximately 9 km south of the entrance of the Beluga River into Cook Inlet. The remaining portions of the action area associated with other project activities (marine transit routes outside Cook Inlet and Prudhoe Bay construction) do not overlap with Cook Inlet beluga whale critical habitat.

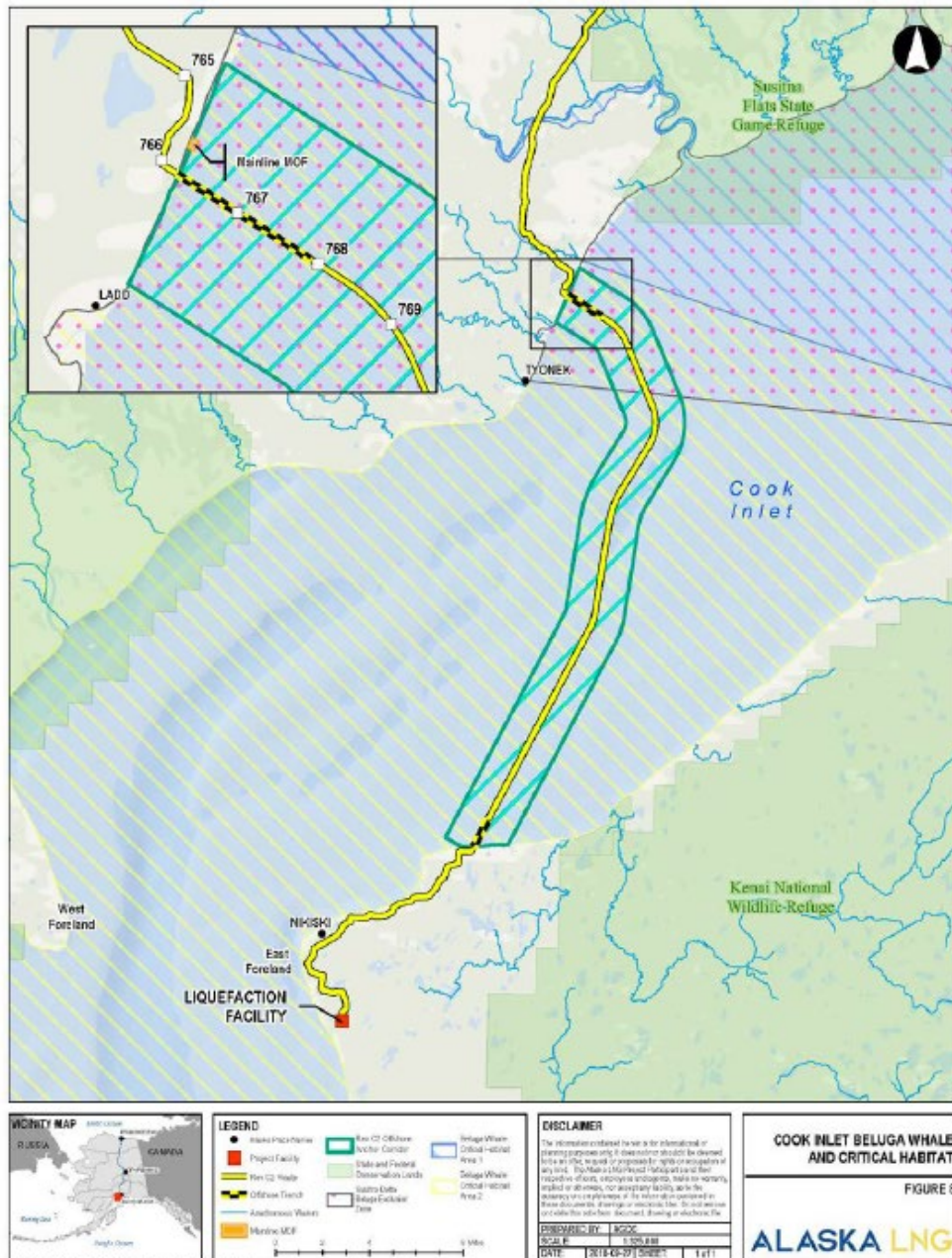


Figure 22. Alaska LNG mainline pipeline Cook Inlet crossing and designated Cook Inlet beluga whale critical habitat.

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; vessel noise; turbidity and sea floor disturbance due to pile driving and dredging; and spills of pollutants.

Notably, as discussed further below, we do not consider natural gas to be among those pollutants that may affect beluga critical habitat given its extreme volatility and lack of harmful residue. The effects of the proposed action on these PBFs are described below.

PBF 1: Intertidal and subtidal waters of Cook Inlet with depths <30 ft (MLLW) and within 5 mi of high and medium flow anadromous fish streams.

Potential impacts to PBF 1 include increased turbidity, elevated 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 5 mi (~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. Based on the use of bubble curtains and other mitigation measures that will be in place during pile driving (Section 2.1.2), we 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 and are therefore insignificant. Impacts from noise on beluga whales and their prey species are discussed below in relation to PBF 2 and in Section 6.3.1 (*Major Noise Sources*) and Section 6.4.12 (*Effects of Noise on Prey Species*).

Pile installation, dredging and disposal, and trenching for pipeline installation may increase turbidity. 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. In general, turbidity associated with pile installation is localized to about a 25-ft (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 for pipeline installation 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, the probability that increased turbidity from the project would occur in waters within this PBF is very low, and thus adverse effects to PBF 1 are extremely unlikely to occur.

Spills may occur at construction sites, during vessel transit (including from bulk carriers), and from leaks in the pipeline. As discussed below in Section 6.4.9 (*Unauthorized Discharges*), small spills are expected to rapidly disperse because of 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, which most beluga prey (fish) will be able to avoid given their mobility. In addition, extreme tidal mixing will greatly reduce the size of the hypoxic plume. We therefore consider the

impact of small spills or natural gas releases upon PBF 1 to be immeasurably small, and thus insignificant.

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 PBF 2 include increased turbidity, elevation in noise levels during pile driving, acoustic and visual disturbance from vessel traffic, and small spills. As described above regarding effects to PBF 1 and in Section 6.4.5 (*Seafloor Disturbance and Habitat Alteration*), pile installation may temporarily increase turbidity resulting from suspended sediments. 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.

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 the primary prey fish species is naturally very low. We therefore conclude that any increases in turbidity will be temporary, localized, and have no measurable impacts to prey species composing this PBF directly, or indirectly through effects to their prey, and thus effects from turbidity on PBF 2 will be insignificant.

As discussed above in Section 6.4.12 (*Effects of Noise on Prey Species*), fish may respond to noise associated with the proposed action (pile driving and vessel traffic) 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 PBF 2 will be immeasurably small. Also, as discussed in section 6.4.12, fish may be disturbed by presence of vessels, or struck, but given 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 PBF 2, 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; Marty et al. 1997; Jewett et al. 2002; Jiang et al. 2017). Small spills of petroleum products and other pollutants are expected to rapidly disperse because of 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, which most beluga prey (fish) will be able to avoid through their mobility. In addition, extreme tidal mixing 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 would 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). Safeguards and spill response plans will be in place to guard against the grounding of bulk carriers (or effects thereof) during the operations phase. In sum, we expect effects to PBF 2 will either be extremely unlikely to occur or immeasurably small and thus insignificant.

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). However, as discussed above regarding effects on PBF 2 and in Section 6.4.9, small spills and leaks are expected to rapidly disperse as a result of tide-induced currents, turbulence, and mixing, and the effects are expected to be extremely small, and thus insignificant. As explained above, we do not consider releases of natural gas (of any size) to be an event that will degrade waters used by beluga whales.

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

PBF 4 may be affected by noise from pile driving activities and anchor handling.

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, belugas were observed swimming through similarly ensonified areas at the Port of Alaska during previous construction and dredging activities (Kendall et al. 2014; Kendall and Cornick 2015; POA 2019a; USACE 2019) and we expect belugas to continue unimpeded during this proposed action. This combined with these additional measures: (1) pile driving will not start if belugas are observed in, or appear likely to enter, the Level B harassment zone or at no less than 1000 m if PSOs cannot monitor the entire zone; and (2) operations will be shutdown whenever a beluga enters or appears likely to enter the Level B zone or at no less than 1000 m if PSOs cannot monitor the entire 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 Area 1 (Figure 22). 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 or at no less than 1000 m if PSOs cannot monitor the entire zone; and operations will be

shut down whenever a beluga enters or appears likely to enter the Level B zone or at no less than 1000 m if PSOs cannot monitor the entire 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 PBF 4 in any measurable amount. The temporary nature of anchor handling in any given location is not expected to restrict passage. Anchor handling will occur primarily offshore, where belugas would be able to easily navigate around the noise source. In addition, anchor handling cannot start until PSOs have monitored a clearance zone and confirmed marine mammals are not present within that zone. While noise associated with these activities may cause temporary behavioral responses in belugas, it will not measurably affect or restrict passage because 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 given the common occurrence of large vessels in the area, and the extremely low velocity exhibited by pipelaying vessels. Deposition of sediment will have no effect on PBF 4; 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.

We therefore conclude that the impact of noise associated with the proposed action is very minor, and thus effects of this stressor on PBF 4 will be insignificant.

PBF 5: 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. 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 (Wartzok et al. 2003; Forney et al. 2017). 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 POA (e.g., 61 North Environmental 2022a; 61 North Environmental 2022c; 61 North Environmental 2025). 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 PBF 5 are extremely unlikely to occur.

In summary, we concur that activities associated with the proposed Alaska LNG project are not likely to adversely affect Cook Inlet beluga whale critical habitat.

4.1.3.4 Mexico DPS and Western North Pacific DPS Humpback Whale Critical Habitat

Critical habitat for Mexico and Western North Pacific DPS humpback whales was designated effective May 21, 2021 (86 FR 21082, April 21, 2021; Figure 23), and includes areas in the eastern Aleutian Islands, the Shumagin Islands, and around Kodiak Island. Critical habitat for the Mexico DPS also includes the Prince William Sound area in Alaska as well as areas along the Washington, Oregon, and California coasts.

For the Mexico DPS, PBFs associated with critical habitat essential to the conservation of the species are prey species, primarily euphausiid zooplankton (*Thysanoessa*, *Euphausia*, and *Nematoscelis* spp.), and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

For the Western North Pacific DPS, the physical and biological features associated with critical habitat essential to the conservation of the species are prey species, primarily euphausiids (*Thysanoessa* and *Euphausia*) and small pelagic schooling fishes, such as Pacific herring, capelin, juvenile walleye pollock, and Pacific sand lance of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

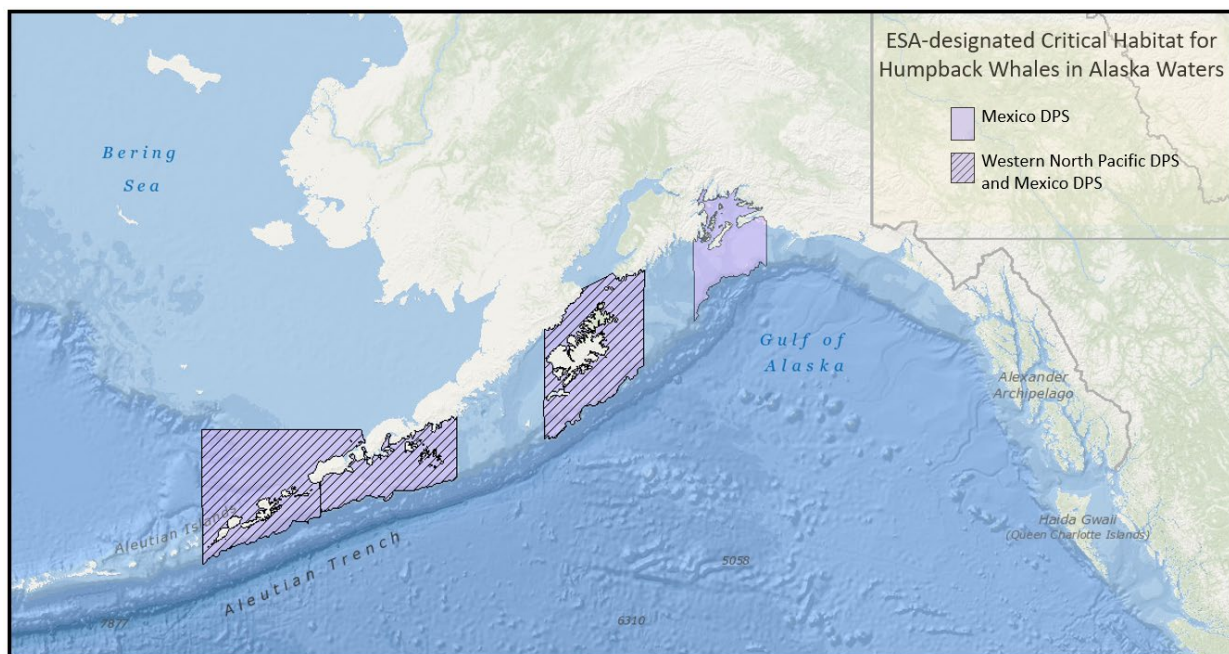


Figure 23. Critical habitat for Mexico DPS and Western North Pacific DPS humpback whales in waters off Alaska.

The potential effects of the action that may overlap with humpback whale critical habitat include acoustic and physical disturbance associated with vessel transit between Dutch Harbor and Prudhoe Bay and to and from the Marine Terminal in Cook Inlet (Nikiski) and exposure to spilled or otherwise-discharged fuel or other chemicals. The remaining portions of the action

area associated with other project activities (marine transit routes in Cook Inlet and Prudhoe Bay and Cook Inlet construction) do not overlap with humpback whale critical habitat. We do not expect the passage of project vessels on the surface of the water or disturbance from transiting vessels to have a measurable effect on essential humpback whale prey species. Vessel sound and the eddies or wake of the vessels across the surface of the water may cause temporary mixing or displacement of a relatively small number of humpback whale prey (include small schooling fishes), but we do not expect that this disturbance would affect the prey distribution or abundance in a meaningful or measurable way. In the event of a small spill occurring in this critical habitat, it would be expected to evaporate, dissipate, or become entrained within 24 hours, such that any effects would be immeasurably small, and thus insignificant. We therefore concur that the proposed action is not likely to adversely affect critical habitat for the Mexico DPS humpback whale or the Western North Pacific DPS humpback whale.

4.1.3.5 Beringia DPS Bearded Seal Critical Habitat

NMFS issued a final rule designating critical habitat for the Beringia DPS of bearded seals in the northern Bering, Chukchi, and Beaufort seas on April 1, 2022 (87 FR 19180) (Figure 24).

The PBFs of critical habitat designated for the Beringia DPS of bearded seals identified as essential to the conservation of the species are: (1) sea ice habitat suitable for whelping and nursing, which is defined as areas with waters 200 m or less in depth containing pack ice of at least 25 percent concentration and providing bearded seals access to those waters from the ice; (2) sea ice habitat as a platform for molting, which is defined as areas with waters 200 m or less in depth containing pack ice of at least 15 percent concentration and providing bearded seals access to those waters from the ice; and (3) primary prey resources to support bearded seals: waters 200 m or less in depth containing benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes (50 CFR 226.229).

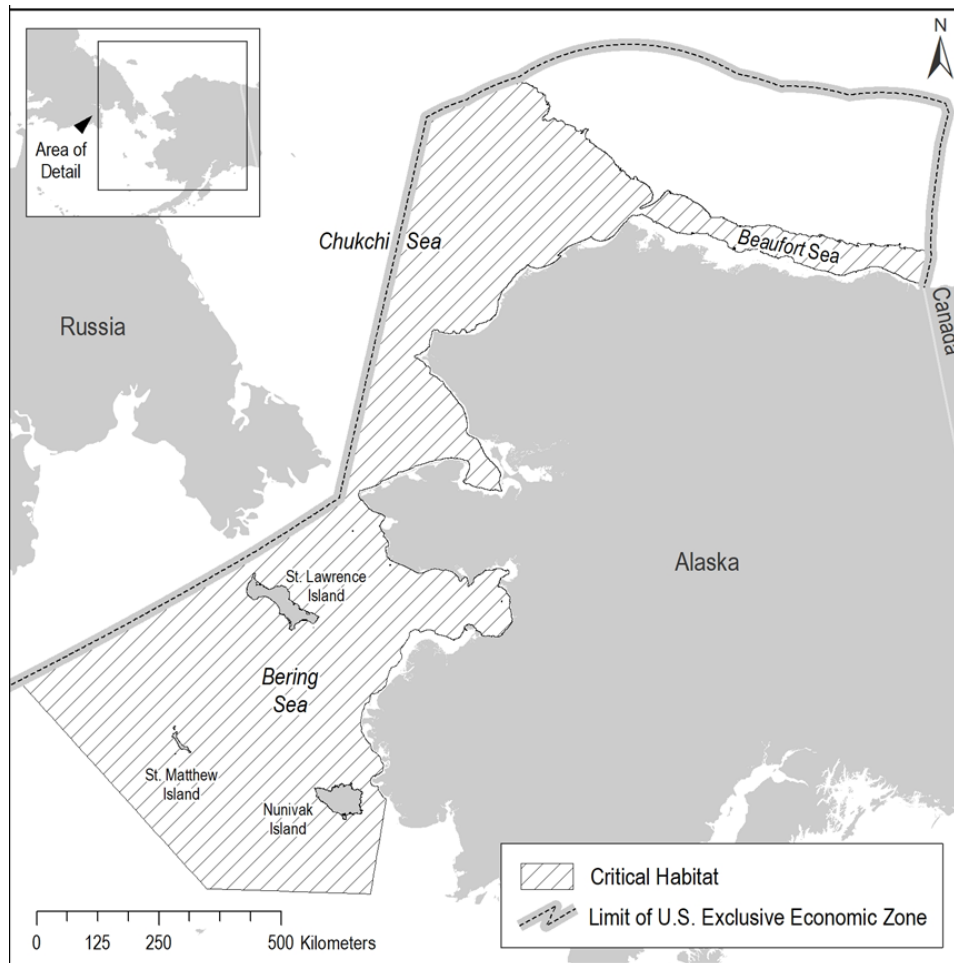


Figure 24. Critical habitat for the Beringia DPS of bearded seals.

Because the shoreward extent of bearded seal critical habitat is defined by the 20-m isobath in the Beaufort Sea, it is located at least 12 km or more seaward of the Prudhoe Bay portion of the action area. Due to this geographic separation, it is extremely unlikely that sound or turbidity produced by the proposed construction activities would impact any of the essential features of bearded seal critical habitat.

The proposed transit route between Dutch Harbor and Prudhoe Bay passes through bearded seal critical habitat. Project vessel transits could cause dispersion or temporary displacement of primary prey resources from feeding areas. However, any such vessel disturbance will be very limited spatially and temporally and is not expected to permanently displace primary prey such that they may not reoccupy this space once the vessel leaves. We therefore do not expect that transiting project vessels would result in an effect on bearded seal primary prey resources that could be meaningfully measured or detected, thus effects of vessel disturbance on bearded seal primary prey resources will be insignificant.

Small spills from project vessels may occur, which could affect bearded seal primary prey resources. However, small spills are expected to dissipate and evaporate rapidly (see also Section 6.4.9). The probability of contamination occurring at harmful concentrations is very low, and in

the event of a small spill, effects on the primary prey resources of bearded seal critical habitat are expected to be immeasurably small. In the event of such a spill, it is highly unlikely to impact sea ice habitat suitable for whelping and nursing which forms over the following winter. Therefore, we conclude that adverse effects of small spills on sea ice suitable for whelping and nursing (or sea ice suitable as a platform for molting) are extremely unlikely to occur.

For the above stated reasons, we concur that the proposed action is not likely to adversely affect critical habitat for the Beringia DPS bearded seals.

4.1.3.6 Arctic Ringed Seal Critical Habitat

NMFS issued a final rule designating critical habitat for the Arctic ringed seal on April 1, 2022 (87 FR 19232). Arctic ringed seal critical habitat comprises an area of marine habitat in the northern Bering, Chukchi, and Beaufort seas (Figure 25).

The following physical and biological features associated with Arctic ringed seal critical habitat were identified as essential to the conservation of the species: (1) snow-covered sea ice habitat suitable for the formation and maintenance of subnivean lairs used for sheltering pups during whelping and nursing, which is defined as waters 3 m or more in depth (relative to mean lower low water, MLLW) containing areas of seasonal landfast (shorefast) ice or dense, stable pack ice, that have undergone deformation and contain snow drifts of sufficient depth to form and maintain birth lairs (typically at least 54 cm deep); (2) sea ice habitat suitable as a platform for basking and molting, which is defined as areas containing sea ice of 15 percent or more concentration in waters 3 m or more in depth (relative to MLLW); and (3) primary prey resources to support Arctic ringed seals, which are defined to be small, often schooling, fishes, in particular, Arctic cod, saffron cod, and rainbow smelt; and small crustaceans, in particular, shrimps and amphipods (50 CFR 226.228).

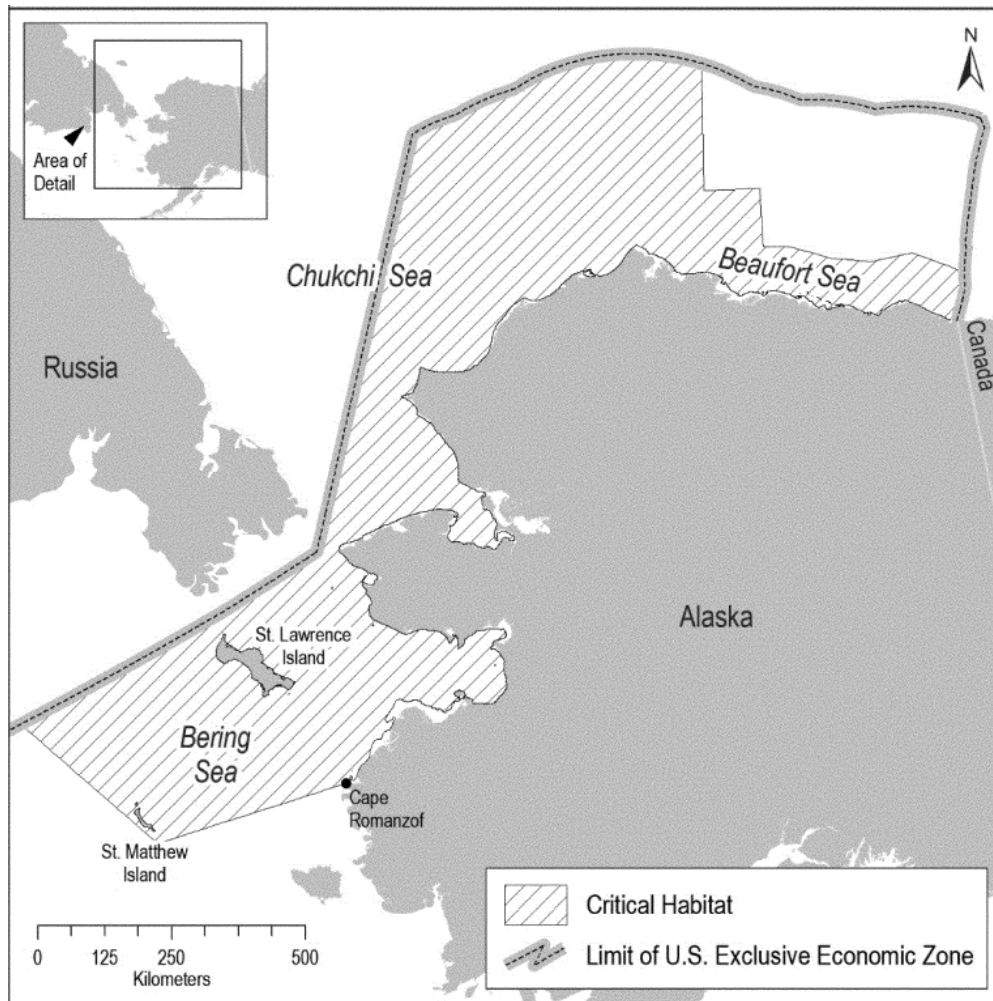


Figure 25. Arctic ringed seal critical habitat.

The shoreward extent of ringed seal critical habitat is defined by the 3-m isobath and it therefore overlaps minimally with the acoustic buffer portion of the action area off Prudhoe Bay in limited areas where water depth is greater than 3 m. The route proposed for seagoing barges and tugs between Dutch Harbor and Prudhoe Bay passes through ringed seal critical habitat. In addition, local project vessel traffic could transit through the critical habitat toward its shoreward boundary. We evaluate effects of the proposed action on each of the essential features of ringed seal critical habitat below.

Sea Ice Habitat Suitable for Subnivean Lairs Used for Whelping and Nursing, and Sea Ice Habitat Suitable as a Platform for Basking and Molting (Essential Features 1 and 2)

Because ringed seal critical habitat overlaps narrowly at its shoreward extent with the outer extent of the Prudhoe Bay portion of the action area, it is possible that sea ice habitat suitable for subnivean lairs used for whelping and nursing could be affected in a very limited part of the southern periphery of the critical habitat should completion of some DH4 construction activities need to occur during the contingency period of February to April. It is unlikely that this essential feature would be impacted by the other construction activities that could occur during this time,

as those activities would be located at least roughly 1.7 km shoreward of the critical habitat and where sea ice is likely to be largely or entirely bottom-fast (i.e., frozen to or resting on the seafloor).

Effects from DH4 construction activities include impacts from noise, presence of construction equipment and personnel, habitat alteration, and small spills. If 8 Star Alaska needs to complete any DH4 construction activities during the contingency period of February to April, 8 Star Alaska will initiate any such work prior to March 1, which is expected to discourage ringed seals from establishing lairs near these activities. Additionally, a subsistence advisor would survey areas within a buffer zone of DH4 where water depth is greater than 3 m to identify potential ringed seal structures before construction activity begins. Construction crews must avoid any identified seal structures by a minimum of 150 m. As such, NMFS expects that physical damage to subnivean lairs (or physical injury to seals in lairs) by construction equipment will be extremely unlikely to occur. In addition, ringed seals hauled on the ice are normally concealed within subnivean lairs, which buffer in-air sound transmission. The impact of noise, presence of construction equipment and personnel, and habitat alteration caused by these activities on sea ice suitable for subnivean lairs used for whelping and nursing pups will therefore be very minor such that effects on this essential feature will be immeasurably small, and thus insignificant. Because ringed seals begin to use sea ice suitable for basking and molting during May, the probability of this essential feature being exposed to noise or presence of construction equipment and personnel associated with the DH4 construction activities (during the contingency period of February-April) is very low, and thus adverse effects on this essential feature are extremely unlikely to occur.

Small spills associated with project vessel transits or construction activities within the Prudhoe Bay portion of the action area may occur, but are expected to dissipate and evaporate quickly in the ocean. In the event of such a spill into the marine environment during the open-water season, it is highly unlikely to impact sea ice habitat suitable for subnivean lairs used for whelping and nursing or as a platform for basking and molting which forms over the following winter. In addition, small spills on top of sea ice (e.g., from construction equipment on sea ice) are subject to normal evaporation and can be easier to contain and clean up, as spreading is controlled to some extent by the snow and ice cover. The impact of a small spill on the sea ice essential features would be very minor such that effects to these essential features would be immeasurably small, and thus insignificant.

Primary Prey Resources (Essential Feature 3)

The proposed action has the potential to affect the primary prey resources essential feature of ringed seal critical habitat through in-water placement of gravel fill (by shore-based equipment), underwater noise, bottom disturbance as a result of pile driving and screeding, and increased turbidity, as well as acoustic and visual disturbance from vessels and small spills. The DH4 construction activities in the Prudhoe Bay portion of the action area will occur at the shoreward extent of ringed seal critical habitat. Gravel would be deposited across 33 acres of the seafloor; and screeding would be conducted over the seafloor to a depth of -4 m MLLW within the approximately 13.7-acre (0.06-km²) berthing area at DH4 prior to arrival of each sealift.

The proposed pile driving, screeding, and related construction activities may temporarily increase turbidity resulting from suspended sediment. However, any increases will be temporary, localized, and minimal. Further, bottom disturbance is a natural and frequent occurrence in this nearshore region resulting in benthic communities with patchy distributions (e.g., Carey et al. 1984). Additionally, installation of DH4 will cover the associated seafloor; however, the total seafloor area that would be affected from installing the structure is a tiny fraction of the habitat within which ringed seal primary prey species occur. The impact of bottom disturbance and increases in turbidity from these activities on ringed seal primary prey resources will be negligible, and thus effects to this essential feature will be insignificant.

The underwater noise generated by pile driving and related activities could cause dispersion or temporary displacement of marine fish (potential ringed seal primary prey resources). The duration of fish avoidance of the disturbed area after pile driving stops is unknown, but we expect a rapid return to normal distribution and behavior. Any behavioral avoidance by fish of the disturbed area would still leave large areas of ringed seal foraging habitat in the nearby vicinity. For these reasons, we conclude that the impact of noise caused by the construction activities in Prudhoe Bay will be immeasurably small, and thus effects to ringed seal primary prey resources will be insignificant.

The proposed transit route between Dutch Harbor and Prudhoe Bay passes through ringed seal critical habitat. Project vessel transits could cause dispersion or temporary displacement of primary prey resources from feeding areas. However, any such vessel disturbance will be very limited spatially and temporally and is not expected to permanently displace primary prey such that they may not reoccupy this space once the vessel leaves. We therefore do not expect that transiting project vessels would result in an effect on ringed seal primary prey resources that could be meaningfully measured or detected, thus effects of vessel disturbance on ringed seal primary prey resources will be insignificant.

Small spills associated with project vessel transits or construction activities within the Prudhoe Bay portion of the action area may occur, but are expected to dissipate and evaporate quickly in the ocean (see also Section 6.4.9). The probability of contamination occurring at harmful concentrations is very low, and in the event of a small spill, effects on the primary prey resources of ringed seal critical habitat are expected to be immeasurably small, and thus insignificant. For the above stated reasons, we concur that the proposed action is not likely to adversely affect critical habitat for the Arctic ringed seals.

In summary, for the reasons stated above, we conclude that any effects of the proposed action on critical habitat for the North Pacific right whale, Steller sea lion, Cook Inlet beluga whale, Mexico DPS humpback whale, Western North Pacific DPS humpback whale, Beringia DPS bearded seal, and Arctic ringed seal will be immeasurably small or extremely unlikely to occur and therefore we concur that this action is not likely to adversely affect these critical habitats.

4.2 Changing Environmental Conditions

Because one threat common to all the species we discuss in this opinion is global changing environmental conditions, we present an overview here rather than in each of the species-specific narratives. A vast amount of literature is available on changing environmental conditions and for

more detailed information we refer the reader to the following websites, which provide the latest data and links to the current state of knowledge on the topic.

<https://www.ipcc.ch/reports/>

<https://science.nasa.gov/climate-change/evidence/>

<https://nsidc.org/home>

<https://arctic.noaa.gov/Report-Card/>

Increased air temperatures, increased ocean temperatures, and ocean acidification are the three facets of changing environmental conditions presented here as they have the most direct impact on marine mammals and their prey, e.g., shifting abundances, changes in distribution, changes in timing of migration, and changes in periodic life cycles of species (IPCC 2019; Huntington et al. 2020; Gulland et al. 2022; Kuletz et al. 2024).

Air Temperature

The Intergovernmental Panel on Climate Change (IPCC 2021) reported that, “[e]ach of the last four decades has been successively warmer than any decade that preceded it since 1850.” The past 10 years (2015–2024) were the warmest since global records began in 1850, and the year 2024 was the warmest year on record.⁵

Recent studies (Sweeney et al. 2023; Zhou et al. 2024) have shown that, after accounting for natural variability, the Arctic (latitude between 60°N and 90°N) has been warming close to three times faster than the global mean since 1980. This is due to “Arctic amplification,” a characteristic of the global climate system influenced by changes in sea ice extent, albedo, atmospheric and oceanic heat transports, cloud cover, black carbon, and many other factors (Serreze and Barry 2011; Richter-Menge et al. 2017; Richter-Menge 2019). Owing to this amplification, the IPCC concluded that, “It is virtually certain that the Arctic will continue to warm more than global surface temperature, with high confidence above two times the rate of global warming.” (IPCC 2021).

Observed Arctic temperatures are already about 2°C higher than the average for the period 1981–2010 (Figure 26). Between 2014 and 2018, Arctic annual surface air temperature exceeded that of any year since 1900. During the winters (January–March) of 2016 and 2018, surface temperatures in the central Arctic were 6 °C above the 1981–2010 average (IPCC 2019). In Alaska, the statewide average annual temperature in 2024 (-1.72°C (28.9°F)) was 1.6°C (2.9°F) above the long-term average, ranking in the warmest third of the historical record for the state.⁶ Over the past 50 years, the greatest warming has occurred over northern and western Alaska, where snow and especially sea ice losses impacted the regional climate (Thoman and McFarland 2024).

⁵ NOAA National Centers for Environmental Information, <https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202413>, accessed September 25, 2025.

⁶ NOAA National Centers for Environmental Information, <https://www.ncei.noaa.gov/access/monitoring/monthly-report/national/202413>, accessed September 25, 2025.

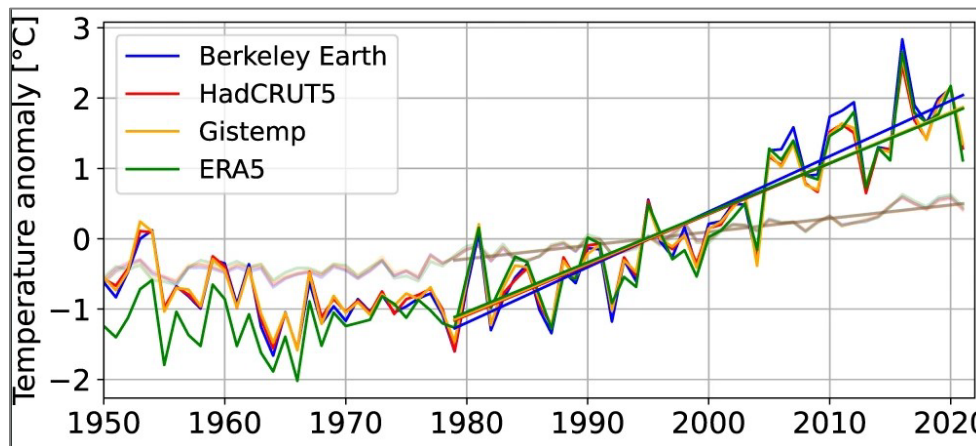


Figure 26. Arctic temperatures have risen close to three times faster than the global average since 1980. Figure and caption from Rantanen et al. (2022): “Annual mean temperature anomalies in the Arctic (66.5°–90°N) (dark colours) and globally (light colours) during 1950–2021 derived from the various observational datasets. Temperature anomalies have been calculated relative to the standard 30-year period of 1981–2010. Shown are also the linear temperature trends for 1979–2021.” Used under the Creative Commons Attribution 4.0 International License.

Marine Water Temperature

Higher air temperatures have led to higher ocean temperatures (IPCC 2021). About 89 percent of the excess heat created by global changing environmental conditions is stored in the world’s oceans, causing increases in ocean temperature (IPCC 2021; von Schuckmann et al. 2023). In each of the past eight years (2017–2024), observed global ocean heat content (OHC) in the upper 2,000 m of the world’s oceans set a new record high (World Meteorological Organization 2025). On a regional level in 2024, the Atlantic and Indian Oceans had their highest OHC in the upper 700 m since the 1950s, while the Pacific had its third highest. Between 1982 and 2024, ocean surface temperatures increased in all of the seas surrounding Alaska. The Chukchi and western Bering seas have shown the greatest change, with summer temperatures averaging 1.7°C (3°F) and 2.4°C (4.3°F) warmer than in the 1980s, respectively (Thoman and McFarland 2024).

Warmer ocean water is among the factors that influence sea ice formation and melt. Arctic sea ice has decreased in surface area, extent, thickness, and season length over the satellite period that extends back to 1979 (IPCC 2021; Meier and Stroeve 2022; Parkinson 2022). Coinciding with the accelerated warming due to Arctic amplification, “Sea ice area has decreased in every month of the year from 1979 to the present (very high confidence),” (IPCC 2021). The last 18 years, from 2007 to 2024, had the lowest Arctic sea ice extents in the satellite record,⁷ and March

⁷ National Snow and Ice Data Center, <https://nsidc.org/sea-ice-today/analyses/arctic-sea-ice-extent-levels-2024-minimum-set>, accessed September 17, 2025.

2025 set a record low maximum ice extent.⁸

The timing of annual freeze-up and melt cycles has also been disrupted, leading to shorter seasonal duration of sea ice coverage. Dauginis and Brown (2021) reported that between 1997 and 2019, the open-water duration across the pan-Arctic increased by 4.85 days per decade. They found that regionally, the Bering and Chukchi seas had the strongest trends toward earlier “ice-off” and later “ice-on,” with the Bering Sea also having the strongest trend toward later “ice on.”

Related to the loss of sea ice is the northward shift and near loss of the cold-water pool in the eastern Bering Sea. Cooling and winter ice formation results in the creation of this cold (<2°C) bottom water (Kinney et al. 2022). With the reduction in winter sea ice, the cold-water pool has shrunk. Many temperate species, especially groundfish, are intolerant of the low temperatures so the extent of sea ice determines the boundary between arctic and subarctic seafloor communities and demersal versus pelagic fish communities (Grebmeier et al. 2006). In the Pacific Arctic, large scale, northward movements of commercial stocks are underway as previously cold-dominated ecosystems warm, and fish move northward to higher latitude, relatively cooler environments (Grebmeier et al. 2006; Eisner et al. 2020). Not only fish, but plankton, crabs and ultimately, sessile invertebrates like clams are affected by these changes in water temperature (Grebmeier et al. 2006; Fedewa et al. 2020).

The marine heat wave, a coherent area of extreme warm temperature at the sea surface that persists, is another ocean water anomaly (Frölicher et al. 2018). Marine heatwaves are a key ecosystem driver and nearly 70 percent of global oceans experienced strong or severe heatwaves in 2016, compared to 30 percent in 2012 (Suryan et al. 2021). The largest recorded marine heat wave occurred in the northeast Pacific Ocean, appearing off the coast of Alaska in the winter of 2013–2014 and extending south to Baja California by the end of 2015 (Frölicher et al. 2018). The Pacific marine heatwave began to dissipate in mid-2016, but warming re-intensified in late-2018 and persisted through 2021 (Suryan et al. 2021; Hastings et al. 2023). Consequences of this event included an unprecedented harmful algal bloom that extended from the Aleutian Islands to southern California, mass strandings of marine mammals, shifts in the distribution of invertebrates and fish, and shifts in abundance of several fish species (Cavole et al. 2016). Cetaceans, forage fish such as capelin and herring, Steller sea lions, adult cod, and Chinook and sockeye salmon in the GOA were all impacted by the Pacific marine heatwave (e.g., Bond et al. 2015; Peterson et al. 2016; Sweeney et al. 2018; Suryan et al. 2021).

Ocean Acidification

For 650,000 years or more, the average global atmospheric carbon dioxide (CO₂) 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; Lüthi et al. 2008). The world’s oceans have absorbed approximately one-third of the anthropogenic CO₂ released, which has buffered

⁸ National Snow and Ice Data Center, <https://nsidc.org/sea-ice-today/analyses/arctic-sea-ice-sets-record-low-maximum-2025>, accessed September 17, 2025.

the increase in atmospheric CO₂ concentrations (Feely et al. 2004, Feely et al. 2009). Despite the oceans' role as large carbon sinks, the CO₂ level continues to rise and is currently over 416 ppm.

As the oceans absorb CO₂, the pH of seawater is reduced. This process is referred to as ocean acidification. Ocean acidification reduces the saturation states of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Bates et al. 2009; Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals, calcification (growth) of shells is favored. Likewise, when the sea water becomes undersaturated, dissolution is favored (Feely et al. 2009).

High latitude (colder) oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters, making Alaska's oceans more susceptible to the effects of ocean acidification (Fabry et al. 2009; Jiang et al. 2015; Terhaar et al. 2020). Model projections indicated that aragonite undersaturation would start to occur by about 2020 in the Arctic Ocean and by 2050, all of the Arctic will be undersaturated with respect to aragonite (Feely et al. 2009; Qi et al. 2017). Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice contribute to the problem by reducing the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite was already detected in the Bering Sea at sampling stations near the outflows of the Yukon and Kuskokwim Rivers, and the Chukchi Sea (Fabry et al. 2009). Models and observations indicate that rapid sea ice loss will increase the uptake of CO₂ and exacerbate the problem of aragonite undersaturation in the Arctic (Yamamoto et al. 2012; DeGrandpre et al. 2020).

Undersaturated waters are potentially highly corrosive to any calcifying organism, such as corals, bivalves, crustaceans, echinoderms and many forms of zooplankton such as copepods and pteropods, and consequently may affect Arctic food webs (Fabry et al. 2008; Bates et al. 2009). 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). Because of their thin shells and dependence on aragonite, under increasingly acidic conditions, pteropods may not be able to grow and maintain shells (Lischka and Riebesell 2012). 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; Lischka and Riebesell 2012).

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. Species 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.

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 an number of published documents including stock assessment reports on Alaska marine mammals by Young et al. (2024a), and recovery plans for fin whales (NMFS 2010c), humpback whales (NMFS 1991a), North Pacific right whales (NMFS 2013d), Steller sea lions (NMFS 2008e), and Cook Inlet beluga whales (NMFS 2016d). Cameron et al. (2010b) provided a status review of bearded seals; and Kelly et al. (2010c) and NMFS (2024d) provided a status review of ringed seals and a 5-year review of four subspecies of ringed seals (including Arctic ringed seals), respectively.

4.3.1 Bowhead Whale

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 (Young et al. 2024a).

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 for subsistence whaling.

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.

The most recent estimates of abundance for the Western Arctic stock were made in 2019; an ice-based survey estimated 14,025 (CV = 0.228) whales (Givens et al. 2023) while an aerial survey estimated 17,175 whales (CV = 0.237; Ferguson et al. 2022). The population has steadily increased in abundance since the 1980s (Givens et al. 2016) and may be approaching carrying capacity (Citta et al. 2023).

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; Citta et al. 2020; Olnes et al. 2020a).

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 late spring and summer (May through September) before migrating again during late summer and fall (September through December) back to the Chukchi Sea and Bering Sea to overwinter (Figure 27) (Young et al. 2024a). A shift after 2012–2013 shows some bowhead whales are remaining in southern Chukchi Sea rather than moving through the Bering Strait and into the northwestern Bering Sea for the winter (Citta et al. 2023; Szesciorka and Stafford 2023). Spring northward migration into the southern Chukchi Sea was earlier in years with less mean January–March Chukchi Sea ice area and delayed in years with greater sea ice area. As sea ice continues to decline, northward spring-time migration could shift earlier or more bowhead whales may overwinter at summer feeding grounds (Szesciorka and Stafford 2023).

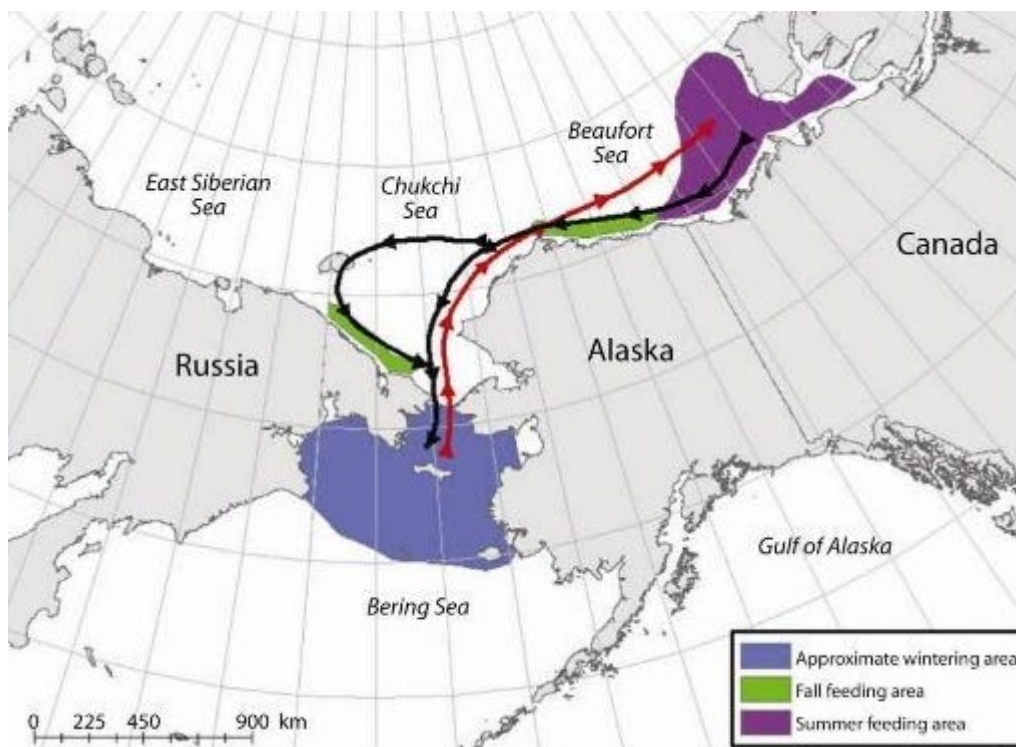


Figure 27. Generalized migration route, feeding areas, and wintering area for Western Arctic bowhead whale (Moore and Laidre 2006).

Occurrence in the Action Area

We expect that bowhead whales may be present within and near the Prudhoe Bay portion of the action area and along the portion of the marine transit route between Dutch Harbor and Prudhoe Bay (as far south as the portion of the route that overlaps with their distribution in the Bering Sea).

The 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. During the proposed Alaska LNG activities, bowhead whales are most likely to be encountered in the fall when they travel closer to shore (than during the spring migration) in the Beaufort Sea, in shelf waters ranging from 15 to 200 m deep (50 to 656 ft) (Miller et al. 2002; Brower et al. 2022c). Druckenmiller et al. (2018) found that between 1982 and 2014, bowhead whales observed during fall in the western Beaufort Sea were closer to the coast when there was less sea ice cover. However, the relationship between fall bowhead whale distribution and sea ice cover is likely more complex, as fall bowhead whale sightings in this region in 2019, when sea ice retreat was extensive, were farther from the coast and in deeper water than in any previous light ice year since 1982 (Clarke et al. 2020).

Clarke et al. (2023) identified biologically important areas (BIAs) for bowheads in the Arctic for bowhead whale migration, reproduction, and feeding. The spring (April and May) migratory BIAs for bowheads are located far offshore from Prudhoe Bay and West Dock but overlap with portions of the proposed marine transit route in the Chukchi and Beaufort seas, while the fall (August–September and October) migratory BIAs for bowheads are located just north of Prudhoe Bay and the associated acoustic buffer portion of the action area and overlap with portions of this transit route (Figure 28). None of the BIAs identified for bowhead whale reproduction overlap with Prudhoe Bay and the associated acoustic buffer portion of the action area; but the August, September, and October reproductive BIAs overlap with parts of the proposed transit route in the Beaufort Sea (Figure 28) (Clarke et al. 2023). Finally, multiple BIAs for bowhead whale feeding were identified (Clarke et al. 2023), several of which may overlap with the outer extent of the Prudhoe Bay acoustic buffer portion of the action area and parts of the proposed transit route in the Beaufort Sea (Figure 29).

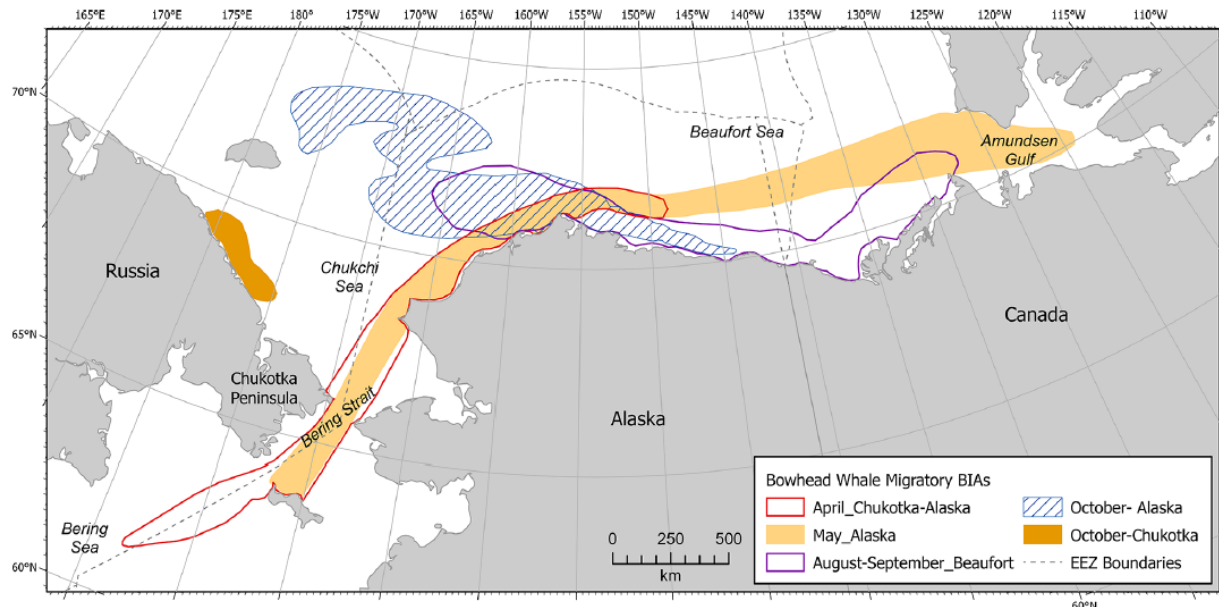


Figure 28. Bowhead whale migratory corridor BIA identified in the Chukchi and Bering seas (Clarke et al. 2023, Figure 7).

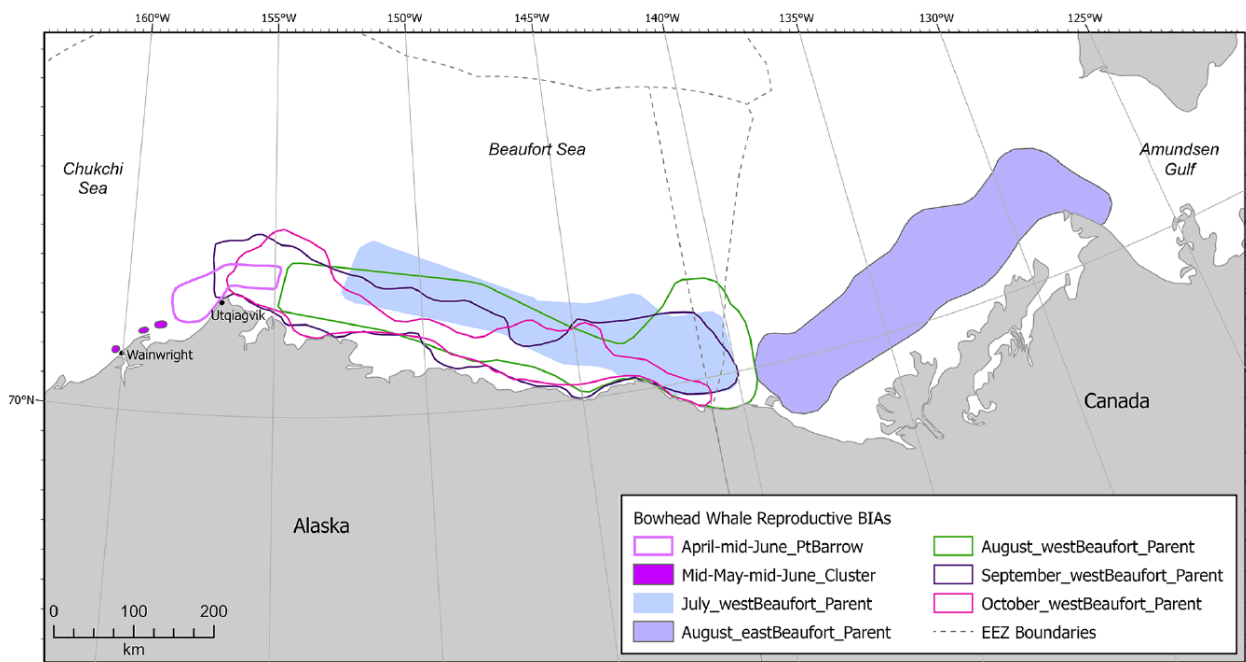


Figure 29. Bowhead whale reproductive BIA identified in the Beaufort Sea and northeastern Chukchi Sea (Clarke et al. 2023, Figure 8).

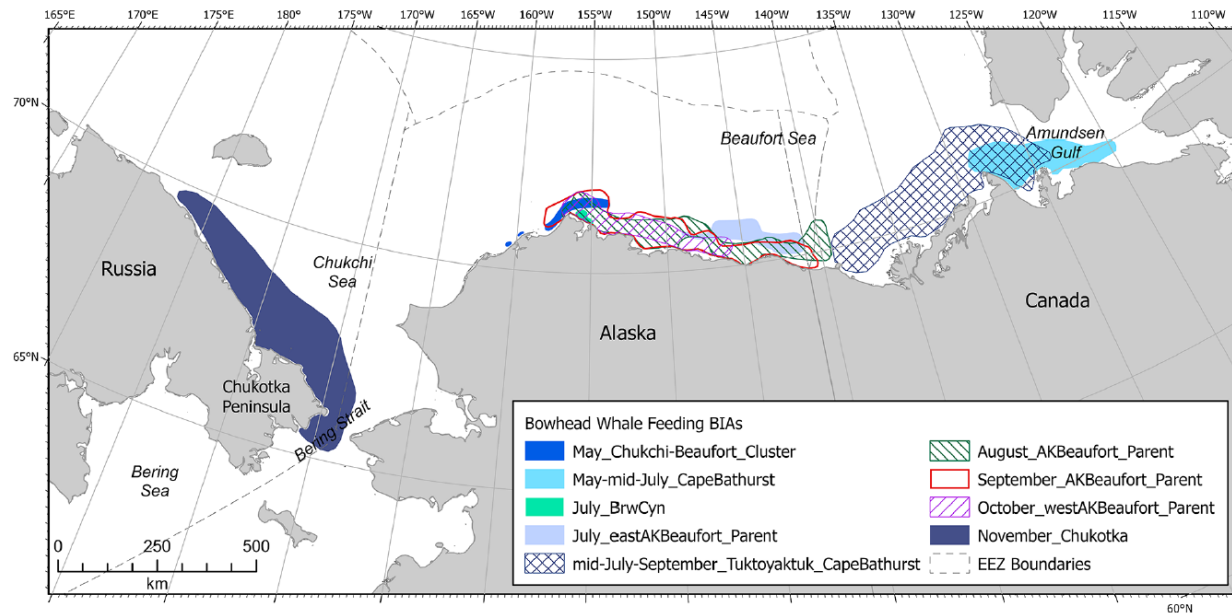


Figure 30. Bowhead whale feeding BIAs identified in the Beaufort and Chukchi seas (Clarke et al. 2023, Figure 6).

Brower et al. (2022a) similarly identified BIAs for bowhead whales in the Bering Sea region (Figure 30). In some instances where information was insufficient to confidently delineate a BIA, the candidate BIA was identified as a watch list area. Two feeding BIAs for bowheads (one active in December and the other in January–April) overlap with the proposed marine transit route through the Bering Strait and the proposed route may also intersect with one or two reproductive watch areas in the Bering Sea depending upon the actual vessel course (Figure 30).

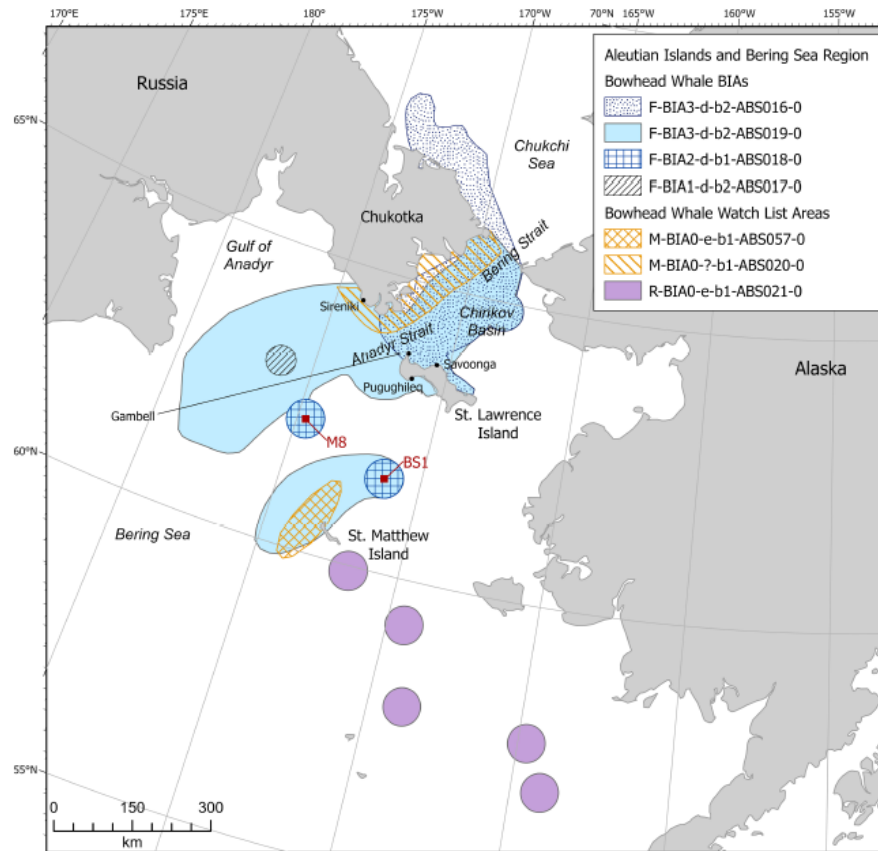


Figure 31. Bowhead whale feeding BIA's in the Bering Sea region; watch list areas for bowhead whale migration (M) and reproduction (R) are also shown (Brower et al. 2022a, Figure 3).

Satellite tracking (2006–2018) data indicate that bowhead whales were generally present in the Alaskan Beaufort Sea between April and October (Citta et al. 2020). In April and May, the whales migrated east past Prudhoe Bay in route to Amundsen Gulf and the Cape Bathurst Polynya (Figure 31). At this time, they were typically north of the shelf break, which is approximately 70 km (43 mi) north of West Dock (Quakenbush 2018). Some tagged whales returned to the Alaskan Beaufort Sea in June and July (Figure 31), prior to the main migration in September and October. Many (but not all) of the June–July movements also occurred north of the shelf break (Figure 31).

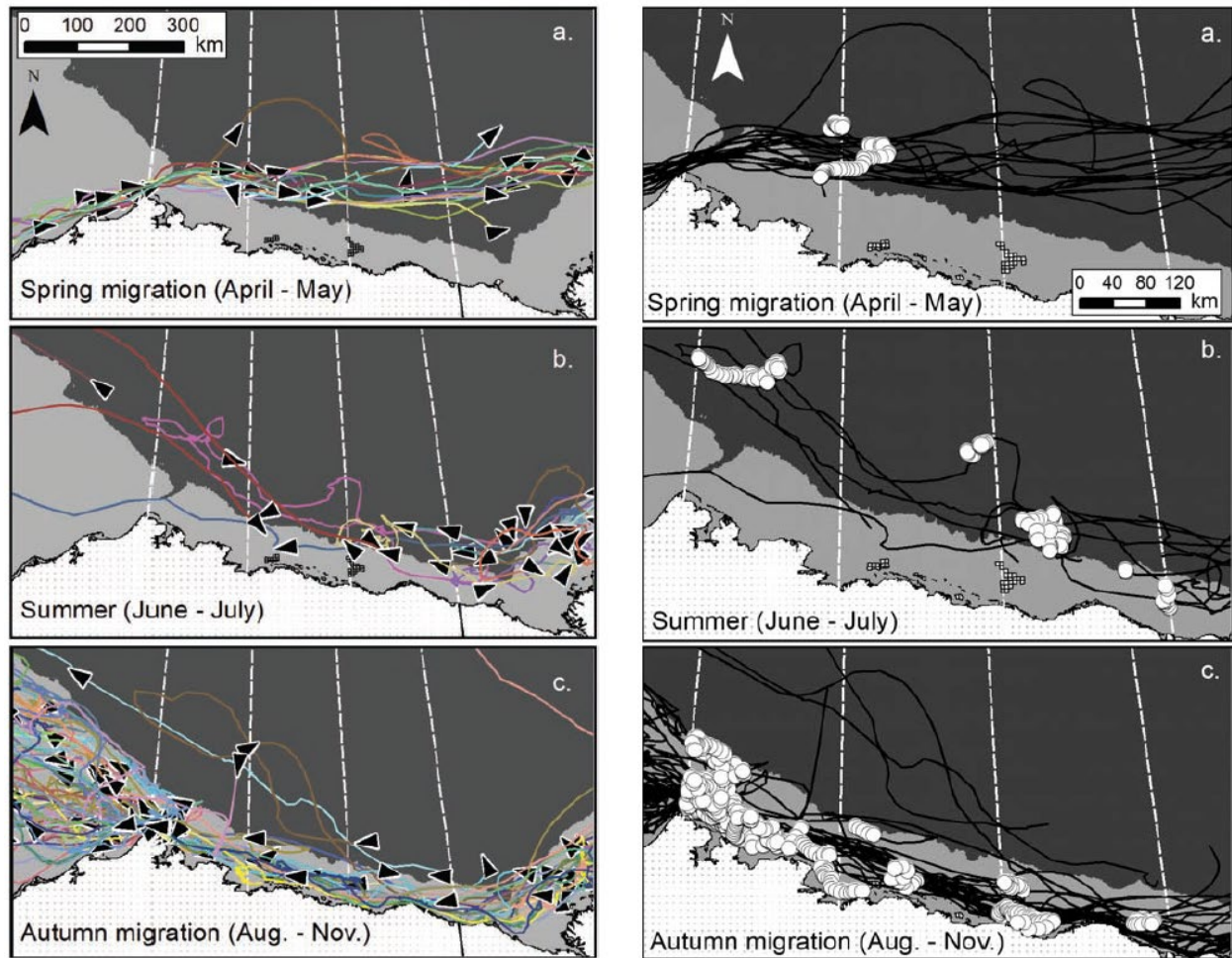


Figure 32. Tracks of 48 satellite-tagged bowhead whales that used the Beaufort Sea off the North Slope of Alaska in 2006–2018 (left panels; colors represent individual whale tracks) and locations where bowhead whales lingered (right panels; white circles), likely reflecting feeding (Olness et al. 2020a, Figure 3).

Tagged whales first began making inshore movements in August (Quakenbush 2018). The large majority of tagged whale movements appeared to be outside the barrier islands (Quakenbush 2018; Olness et al. 2020a). The main fall migratory corridor for tagged whales extended approximately 40 km (25 mi) north from the barrier islands (Quakenbush 2018).

The main feeding area (lingering locations likely reflecting feeding) of the tagged animals in the Alaskan Beaufort Sea was west of Cape Halkett (approximately 180 km [112 mi] west of Prudhoe Bay) (Figure 31). Tagged bowhead data also showed limited feeding behavior in Camden Bay (approximately 10 km [6.2 mi] east of Prudhoe Bay) (Figure 31), where one whale lingered for four days and another lingered for nine days in 2010 (Quakenbush 2018). Migrating (i.e., non-feeding) tagged bowhead whales spent an average of 2 days in the Prudhoe Bay area (Quakenbush et al. 2013). There were 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 occur in the Prudhoe Bay area in summer and fall (Quakenbush 2018; Olness et al. 2020a).

During summer seismic surveys conducted in nearby Foggy Island Bay (~30 km east of Prudhoe Bay) in 2008, only one cetacean sighting was documented by PSOs 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 (Smultea et al. 2014; Cate et al. 2015). From 2001 through 2004, 95 percent of bowhead whales detected during fall acoustic monitoring at Northstar (~18 km northwest of Prudhoe Bay) 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.⁹ Through these projects, aerial surveys have been conducted in the Alaska Beaufort Sea in late summer and autumn between 1979 and 2019. The ASAMM study area did not include waters inside the barrier islands near the coast before 2016; however, transects within Survey Block 1 (between roughly Oliktok Point and Flaxman Island), that runs through Prudhoe Bay, were extended to include these waters beginning in 2016. Figure 32 and Figure 33 display sightings of bowhead whales in light ice years between 1982 and 2019 during July–August and September–October, respectively. Surveys were subsequently conducted in 2020 and 2021 from mid-September through mid-October—focused on the area ranging from Utqiagvik (formerly Barrow) to Prudhoe Bay—using methods consistent with the ASAMM surveys (Brower et al. 2022b; Brower et al. 2022c).

As mentioned above, 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 in the Prudhoe Bay portion of the action area were estimated using the aerial survey results from 2011 through 2019 and 2011–2021, respectively (Clarke et al. 2012; Clarke et al. 2013b; Clarke et al. 2014; Clarke et al. 2015; Clarke et al. 2017b; Clarke et al. 2017a; Clarke et al. 2018; Clarke et al. 2019; Clarke et al. 2020; Brower et al. 2022b; Brower et al. 2022c). 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 surveys.

Bowhead whale densities were calculated in a two-step approach; first a sighting rate of whales per km was calculated, then the sighting rate was divided by two times the effective strip width (in order to encompass both sides of the transect line) using the modeled species-specific effective strip width for an Aero Commander airplane of 1.15 km (CV = 0.08) calculated by Ferguson and Clarke (2013):

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

⁹ The ASAMM database and annual reports are available from the NMFS Marine Mammal Laboratory web page <https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/aerial-surveys-arctic-marine-mammals>.

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 between the barrier islands and mainland.

Table 31. Estimated bowhead whale densities based on data from ASAMM Survey Block 1.

Summer (Jul-Aug)					Fall (Sept-Oct)			
Year	On-Transect Effort (km)	On-Transect Sightings	Sighting Rate (whales/km)	Density (whales/km ²)	On-Transect Effort (km)	On-Transect Sightings	Sighting Rate (whales/km)	Density (whales/km ²)
2011	346	1	0.002890	0.001257	1,130	24	0.021239	0.009234
2012	1,493	5	0.003349	0.001456	1,696	17	0.010024	0.004358
2013	1,582	21	0.013274	0.005771	1,121	21	0.018733	0.008145
2014	1,393	17	0.012204	0.005306	1,538	79	0.051365	0.022333
2015	1,262	15	0.011886	0.005168	1,663	17	0.010222	0.004444
2016	1,914	97	0.050679	0.022034	2,360	23	0.009746	0.004237
2017	3,003	8	0.002664	0.001158	1,803	255	0.141431	0.061492
2018	2,491	2	0.000803	0.000349	1,535	69	0.044951	0.019544
2019	1,643	6	0.003652	0.001588	2,055	45	0.021898	0.009521
2020	NA	NA	NA	NA	379	54	0.142480	0.061948
2021	NA	NA	NA	NA	668	15	0.022455	0.009763
Encounter Rate (whales/km)				0.011370	Encounter Rate (whales/km)			0.038814
Density (whales/km ²)				0.004944	Density (whales/km ²)			0.016876

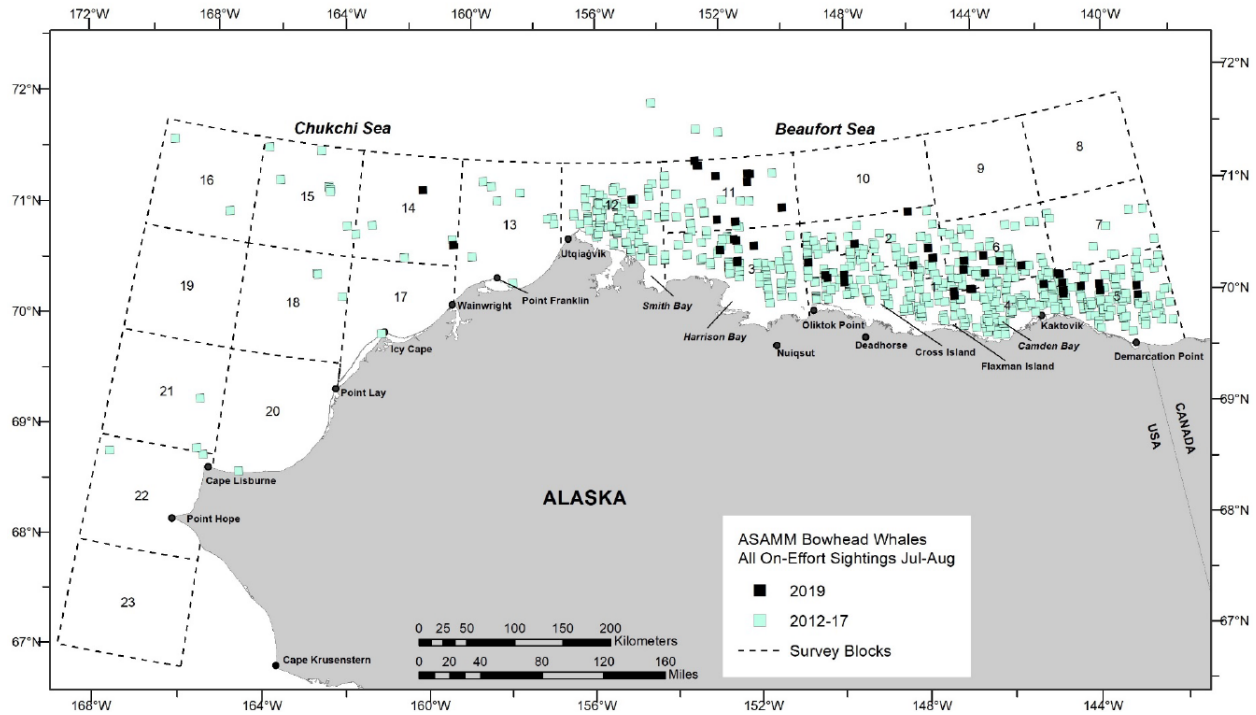


Figure 33. Summer (July–August) bowhead whale sightings from Aerial Surveys of Arctic Marine Mammals (ASAMM) in light ice years (1982, 1986–1987, 1989–1990, 1993–2017, and 2019) (Clarke et al. 2020, Figure 19).

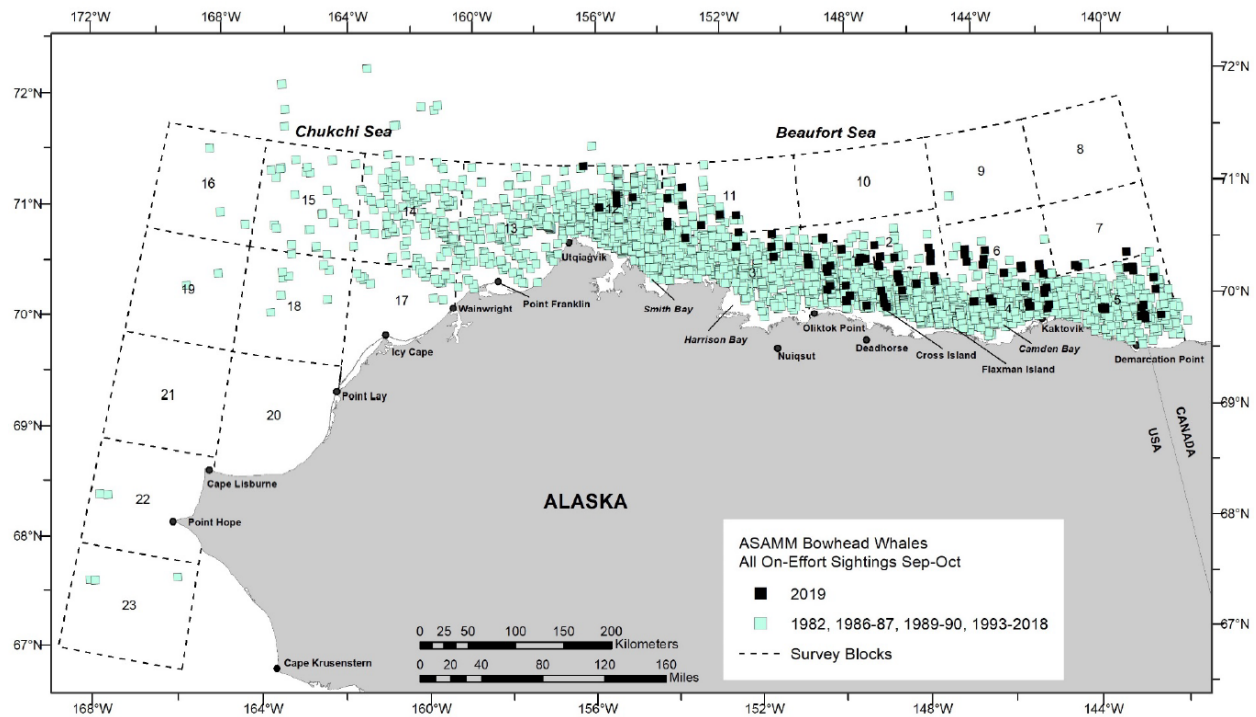


Figure 34. Fall (September–October) ASAMM bowhead whale sightings in light ice years (1982, 1986–1987, 1989–1990, 1993–2018, and 2019) (Clarke et al. 2020, Figure 20).

Feeding and Prey Selection

Evidence suggests that bowhead whales feed primarily on small zooplankton throughout their range (Sheffield and George 2021). 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). 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.

Western Arctic bowhead whales feed in the shelf waters 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 produce a wide variety of sounds. Their calls, which are produced year-round, are mainly at a fairly low frequency (generally, ~25–500 Hz) and of short duration (reviewed in Stafford and Clark 2020). Most underwater calls are at a fairly low frequency and easily audible to the human ear. In contrast to calls, bowhead whale songs are produced seasonally (mainly during winter and spring months) and generally range from 50 Hz to 5 kHz, with singing lasting from minutes to many hours (reviewed in Stafford and Clark 2020; Stafford 2022).

Erbe (2002) reported that, “Inferring from their vocalizations, bowheads should be most sensitive to frequencies between 20 Hz to 5 kHz, with maximum sensitivity between 100 Hz and 500 Hz.” NMFS categorizes bowhead whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group, with a generalized hearing range¹⁰ of 7 Hz to 36 kHz (NMFS 2024b).

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

¹⁰ NMFS determined generalized hearing ranges for each hearing group based on the ~65 dB threshold from composite audiograms.

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; Noongwook et al. 2007b). In addition, whalers wear white parkas on the ice so that they are not visible to the whales when they surface (Rexford 1997; Noongwook et al. 2007b).

Olfaction may also be important to bowhead whales. 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 Beringia DPS Bearded Seal

Status and Population Structure

NMFS published a final rule to list the Beringia DPS of the *Erignathus barbatus nauticus* subspecies of bearded seal as threatened under the ESA on December 28, 2012, primarily due to threats associated with long-term reductions in sea ice expected to occur within the foreseeable future stemming from changing environmental conditions (77 FR 76740). NMFS has not finalized a recovery plan for the Beringia DPS.

A reliable population estimate for the entire Beringia DPS is not available (Young et al. 2024a). However, as discussed by Young et al. (2024a), using a limited sub-sample of spring aerial survey data collected from the U.S. portion of the Bering Sea in 2012, Conn et al. (2014) calculated a preliminary abundance estimate of 301,836 bearded seals (95 percent confidence interval: 238,195–371,147) in these waters. In addition, results from a spring aerial survey of the Chukchi Sea in 2016 produced an estimate of 147,421 (95 percent confidence interval: 114,155–190,380) bearded seals in the Chukchi Sea (Boveng et al. 2025).

Distribution and Habitat Use

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. (2010b) 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, although their effective habitat is generally restricted to areas where seasonal ice occurs over relatively shallow waters, typically less than 200 m, where they can reach the ocean floor to forage (Burns and Frost 1979a; Burns 1981; Nelson et al. 1984; Fedoseev 2000).

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 (Heptner et

al. 1976; Fedoseev 1984; Nelson et al. 1984). They usually avoid areas of continuous, thick, landfast (shorefast) ice and are rarely seen in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Burns and Harbo 1972; Burns and Frost 1979a; Burns 1981; Smith 1981; Fedoseev 1984; Nelson et al. 1984). 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).

In late winter and early spring, many bearded seals are widely but not uniformly distributed in broken, drifting pack ice in the Bering Sea (Burns 1981; Braham et al. 1984). Some bearded seals also inhabit suitable pack ice in the Chukchi and Beaufort seas over winter and spring (Jones et al. 2014b; MacIntyre et al. 2015a; Frouin-Mouy et al. 2016; Olnes et al. 2020b; Quakenbush 2020b). As the ice recedes in spring, many of the bearded seals that overwintered in the Bering Sea migrate north through the Bering Strait and spend the summer along the ice edge in the Chukchi and Beaufort seas, though some remain in open-water areas from the Bering Sea north (Burns 1981; Olnes et al. 2020b; Quakenbush 2020b).

During the open-water season, some bearded seals (largely juveniles) occur in small bays, lagoons, near river mouths, and up some rivers, particularly in late summer and fall (Oceana and Kawerak 2014; Northwest Arctic Borough 2016; Gryba et al. 2021). While adult bearded seals have rarely been seen hauled out on land in Alaska (Burns 1981; Nelson 1981), (solitary) juvenile bearded seals have been observed or documented via satellite telemetry during the open-water season hauled out on land in some areas (Oceana and Kawerak 2014; Gadamus et al. 2015; Olnes et al. 2020b).

Occurrence in the Action Area

We expect that bearded seals may be present along the proposed marine transit route between Dutch Harbor and Prudhoe Bay, as well as within and near the Prudhoe Bay portion of the action area during the open-water season when the majority of the Alaska LNG activities will occur. Because of the more extensive foraging habitat available to bearded seals in the Chukchi Sea, the Beaufort Sea likely supports fewer bearded seals than the Chukchi Sea during the open-water season. 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 (Green and Negri 2006; Green et al. 2007; Hauser et al. 2008; Funk et al. 2010a; Brandon et al. 2011; Reiser et al. 2011). In addition, eight bearded seal sightings were documented during shallow geohazard seismic and seabed mapping surveys conducted north of Prudhoe Bay in July and August 2014 (Smultea et al. 2014). Frouin-Mouy et al. (2016) conducted acoustic monitoring in Foggy Island Bay (~30 km east of Prudhoe 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 2 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. 2015a), most bearded seals

overwinter in the Bering Sea. In addition, during late winter and early spring, Prudhoe Bay is covered with landfast 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.

Both bearded seals and ringed seals are most readily observed in late spring and early summer when they haul out on the surface of the sea ice to molt. Therefore, most abundance and distribution surveys of these species are conducted during this time. From 1999 through 2002, aerial surveys conducted during late spring in association with construction and oil production activities at Northstar (which is located ~18 km northwest of Prudhoe Bay) documented 47 bearded seals (annual mean of 11.75 seals during an annual mean of 3,997.5 km² of effort, Table 32) (Moulton et al. 2000; Moulton et al. 2001; Moulton et al. 2002; Moulton et al. 2003). While densities were not reported because of the small numbers of bearded seals observed, no other data are currently available on Beaufort Sea bearded seal densities. Therefore, NMFS estimated bearded seal density for winter and spring in the Prudhoe Bay portion of the action area at 0.003 seals/km² based on the four years of aerial survey data (Table 32).

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 (km²)	Bearded Seal Density (seals/km²)	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. (2002)
2002	9	3,618	0.002	Moulton et al. (2003)
Average	11.75	3,997.5	0.003	

Figure 35 displays the bearded seals observed in 1999 (the year with the most observations). This figure provides a reasonable representation of general distribution of bearded seals observed over all 4 years. Annual reports for years 2000 through 2002 (Moulton et al. 2001; Moulton et al. 2002; Moulton et al. 2003) include similar figures.

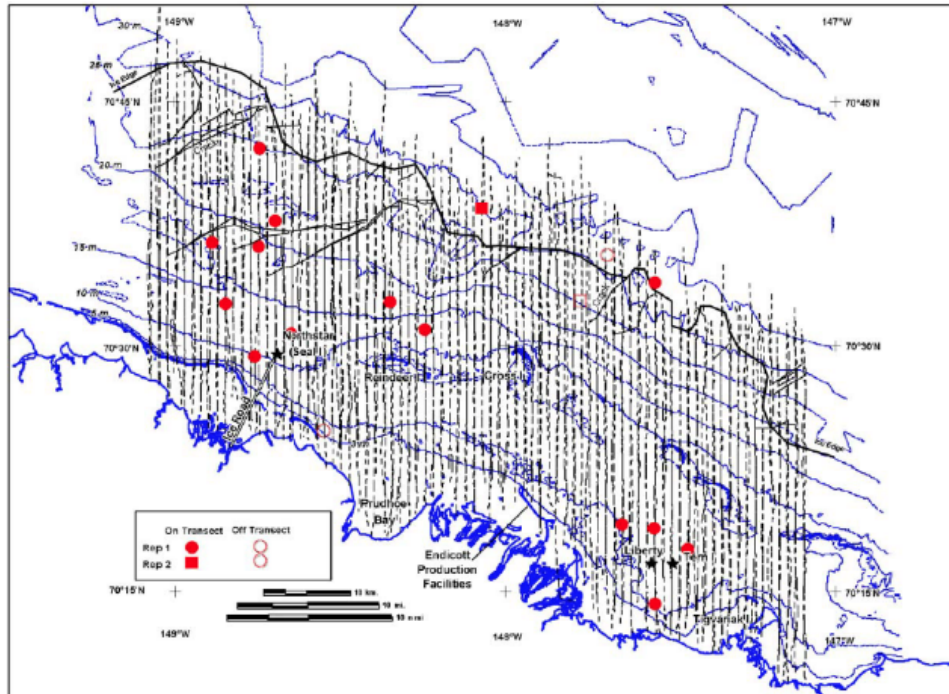


Figure 35. Distribution of bearded seal sighting during Northstar aerial surveys, June 4–13, 1999 (Moulton et al. 2000).

To estimate the density of bearded seals in the Prudhoe Bay portion of the action area during the open-water season (summer and fall), sighting data from vessel-based monitoring conducted in the Beaufort Sea from 2006 through 2008 were used (Funk et al. 2010a). Of all the individual seals identified to species ($n = 1,213$) during the monitoring surveys, 63.8 percent were ringed seals and 13.6 percent were bearded seals, a ratio of 0.213 bearded seals per ringed seal. Bearded seal density was calculated as a proportion of the ringed seal summer density of 0.32 seals/km² discussed below in Section 4.3.3 (To note, as explained below, NMFS used a revised approach to calculate the ringed seal winter-spring density estimate, which results in a different ringed seal summer density estimate. Because the ringed seal summer density estimate is used to estimate the density of bearded seals in the summer and fall, the bearded seal density is also different than previously calculated). Thus, the density of bearded seals during the open water season (summer and fall) was calculated as 21.3 percent of 0.32 seals/km², resulting in an estimate of 0.068 seals/km².

Feeding and Prey Selection

Bearded seals feed primarily on benthic organisms, including a variety of epifaunal and infaunal invertebrates, and demersal fishes; however their diet also includes pelagic fishes (Cameron et al. 2010b; Quakenbush 2020a). Quakenbush (2020a) found that bearded seals harvested for subsistence in the northern Bering and Chukchi seas during 2000 through 2019 consumed many species of fish and invertebrates. The most prevalent invertebrate groups were shrimp, crabs, and bivalve mollusks; and the most prevalent fish groups were sculpins and righteye flounders, though small cods (Arctic cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*)) were also important. Bearded seals are believed to detect benthic prey by scanning the surface of the seafloor with their highly sensitive whiskers (Marshall et al. 2006). They are considered

opportunistic feeders whose diet varies with age, location, season, and changes in prey availability.

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 et al. 2001; Van Parijs 2003; Van Parijs et al. 2003; Van Parijs et al. 2004; Van Parijs and Clark 2006).

Hearing thresholds in water for tonal sounds were obtained by Sills et al. (2020) for two captive bearded seals at frequencies between 100 Hz and 61 kHz under quiet conditions. The seals showed sensitive underwater hearing abilities, with the lowest measured threshold near 50 dB re 1 μ Pa. The range of best hearing extended from approximately 300 Hz to 45 kHz and the full range of hearing extended from below 100 Hz to at least 60 kHz.

Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, and make calls between 90 Hz and 16 kHz. NMFS defines the underwater and in-air generalized hearing ranges for phocids (including bearded seals) as 40 Hz to 90 kHz and 42 Hz to 52 kHz, respectively (NMFS 2024b).

4.3.3 Arctic Ringed Seal

Status and Population Structure

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 changing environmental conditions within the foreseeable future (77 FR 76706).

A reliable range-wide population estimate for Arctic ringed seals is not available. As discussed by Young et al. (2024a), Conn et al. (2014) calculated an abundance estimate of 174,418 ringed seals (95 percent confidence interval: 141,588–201,090) in the U.S. Bering Sea using a limited sub-sample of spring aerial survey data collected in 2012. Because this estimate did not account for availability bias or include ringed seals in landfast ice, the actual number of ringed seals in these waters is likely much higher (Young et al. 2024a). Results from a spring aerial survey of the Chukchi Sea in 2016 produced an estimate of 592,577 (95 percent confidence interval: 478,448–733,929) ringed seals in the Chukchi Sea (Boveng et al. 2025). A 2021 survey of the Beaufort Sea by NMFS (analysis pending), in combination with the previous surveys in the Bering and Chukchi seas (Boveng et al. In Prep), will allow for the determination of an estimate of ringed seal abundance in waters surrounding Alaska. It is anticipated that the total estimate of ringed seals in this region will exceed 1 million individuals (NMFS 2024d).

Distribution and Habitat Use

Arctic ringed seals are highly associated with sea ice, which they use as a platform for whelping and nursing pups in spring, molting in spring to early summer, and resting throughout the year (Kelly et al. 2010c) (Figure 36). Ringed seals are able to open and maintain breathing holes in the ice, which allows them to inhabit heavily ice-covered areas. Although ringed seals use both pack ice and landfast ice, they have been reported to favor landfast ice as whelping habitat (e.g., Smith and Stirling 1975; Smith and Stirling 1978; Smith et al. 1991; Pilfold et al. 2014).

At some breathing holes with sufficient snow cover, ringed seals excavate lairs in snowdrifts on the surface of the ice within which they rest and give birth to and nurse pups (Smith and Stirling 1975; Williams et al. 2006; Hauser et al. 2021). These subnivean lairs are important to pup survival because they provide shelter from extreme cold and concealment from predators (Lukin and Potelov 1978; Smith et al. 1991; Stirling and Smith 2004). Pups are nursed in the lairs for an average of 39 days (Hammill et al. 1991), with considerable variation (Kelly et al. 2010c). Numbers of ringed seals hauled out on the surface of the ice typically begin to increase during late spring as the temperatures warm and the snow covering the seals' lairs melts. The ice serves as a substrate for annual molting, during which time the seals spend many hours basking in the sun (e.g., Smith and Hammill 1981; Kelly and Quakenbush 1990; Kelly et al. 2010c).

During winter and spring, ringed seals are found throughout the Chukchi and Beaufort seas (Frost 1985; Kelly 1988), and aerial surveys indicate that they are found throughout nearly the entire ice field over the Bering Sea shelf (Braham et al. 1984; Lindsay et al. 2021). Adult ringed seal movements during winter and spring have been reported as typically localized, especially where ice cover is extensive (Kelly and Quakenbush 1990; Harwood et al. 2007; Kelly et al. 2010a; Crawford et al. 2012; Luque et al. 2014; Quakenbush et al. 2019a), likely due to maintenance of breathing holes and social behavior during the breeding season (Kelly et al. 2010a). During January through May, radio-tagged adult ringed seals inhabiting landfast ice near Prudhoe Bay had home range sizes that ranged from less than 1 km² to 27.9 km², although most home ranges were less than 3 km² (Kelly et al. 2010a).

Most ringed seals that winter in the Bering and southern Chukchi seas are thought to migrate north in spring as the ice recedes (Frost 1985). Tracking data indicate that ringed seals extensively use the continental shelf waters of the Chukchi and Beaufort seas during the open-water season, and some seals make excursions into deep waters north of the shelf break (Crawford et al. 2012; Quakenbush 2020b; Von Duyke et al. 2020). Ringed seals (primarily juveniles) have also been observed near river mouths and in lagoons in some areas during the open-water season, especially during fall (Oceana and Kawerak 2014; Gryba et al. 2021).

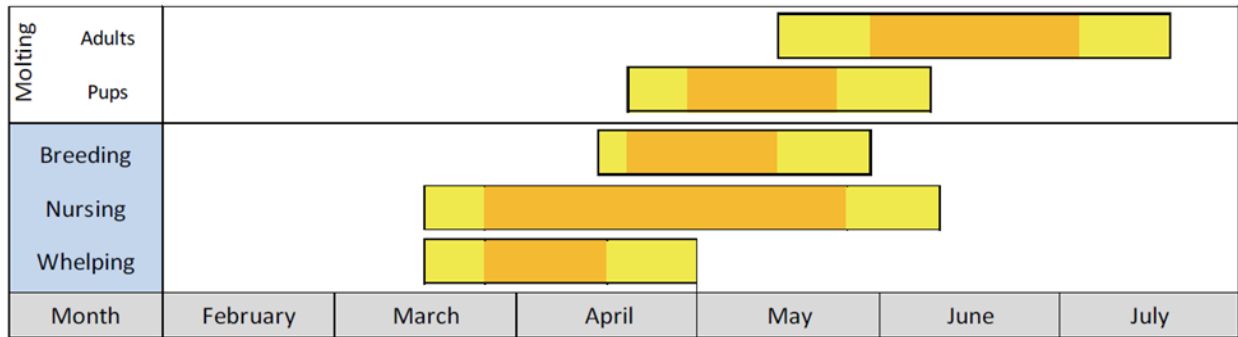


Figure 36. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicate the “peak” timing of each event (Kelly et al. 2010c).

Occurrence in the Action Area

Given their widespread distribution, ringed seals may be present within and near the Prudhoe Bay portion of the action area and along the proposed marine transit route between Dutch Harbor and Prudhoe Bay. Funk et al. (2010a) reported that ringed seals were the most frequently identified seal species recorded by vessel-based marine mammal observers in the Beaufort Sea during Shell’s marine mammal monitoring in 2006 to 2008. They have been observed during vessel-based monitoring in nearby Foggy Island Bay (~30 km east of Prudhoe Bay) in relatively low numbers (Aerts et al. 2008; Funk et al. 2008; Funk et al. 2010a; Smultea et al. 2014), and during monitoring from Northstar Island (~18 km northwest of Prudhoe Bay) during the last part of the ice-covered season and the start of the open-water season (Aerts and Richardson 2009; Aerts and Richardson 2010).

Landfast ice occupies Prudhoe Bay from winter to break-up in late spring to early summer. As noted above, ringed seals have been reported to favor landfast ice as whelping habitat. However, 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 water (bottomfast ice) during the course of the winter (Moulton et al. 2005). Where landfast sea ice is bottomfast, there would presumably be little to no ice-free water present that would allow the seals to swim under and gain access to the ice surface for the construction and maintenance of birth lairs, except perhaps where cracks form in the ice, or where the ice is not uniformly frozen to or resting on the seafloor.

Aerial surveys flown in 1997 through 2002 (Moulton et al. 2005) and 1996 through 1999 (Frost et al. 2004) in the central Beaufort Sea during late May and early June—when the greatest percentage of seals have abandoned their lairs and are hauled out on the ice (Kelly et al. 2010c)—provide the best available information on winter and spring ringed seal densities in the Prudhoe Bay portion of the action area. The study area of Frost et al. (2004) was larger than that of Moulton et al. (2005), but it included the same, smaller study area of Moulton et al. (2005), which extended from west of Prudhoe Bay to Foggy Island Bay (Figure 37). Frost et al. (2004) recalculated observed ringed seal densities from their surveys in 1997 through 1999 for only that smaller survey area and found that their observed densities were consistently higher than those reported by Moulton et al. (2005) for the same survey area (0.73 vs. 0.43 seals/km² for 1997, 0.64 vs. 0.39 seals/km² in 1998, and 0.87 vs. 0.63 seals/km² in 1999). NMFS therefore estimated

winter–spring ringed seal density using the results from both studies shown in Table 33. NMFS looked at all available data presented in recent incidental harassment applications and ruled out a number of surveys based on the age of the survey. NMFS also excluded the aerial surveys from Frost and Burns (1989) and Frost and Lowery (1987) because that data was extremely dated, and then ran a straight mean on these surveys since no large outliers in the data were observed. This approach results in a slightly higher ringed seal spring density than previously estimated, and, after accounting for the lower density in the summer and fall, a different summer–fall ringed seal density than previously estimated.

Based on the average observed density (i.e., density of seals visible on the ice; not corrected for availability or detectability bias) across survey years, the density of ringed seals during winter and spring is estimated to be 0.634 ringed seal/km². Densities are expected to be much lower during summer and fall, as ringed seals range substantial distances during the open water season. Summer–fall ringed seal density was estimated to be 50 percent of the winter–spring density, resulting in a density of 0.317 seals/km². This 50 percent estimate is consistent with prior analyses.

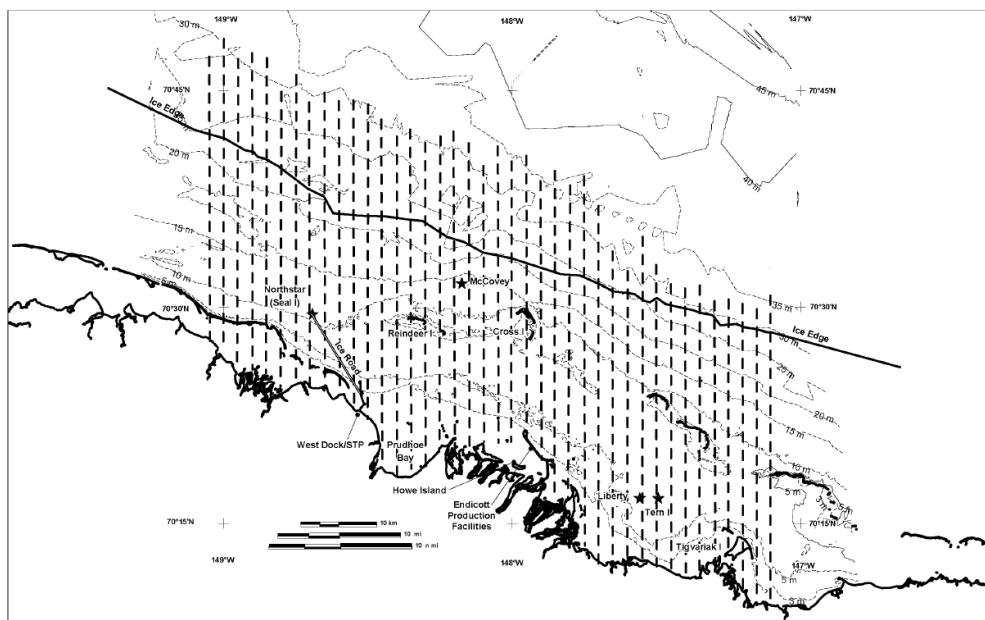


Figure 37. Ice seal aerial survey transects flown in late May to early June 2002; a set of 40 transects offset from these transects by 0.5 nm (0.93 km) to the east was also flown (Moulton et al. 2003). Similar aerial surveys were conducted in each year, 1997–2001 (Moulton et al. 2005).

Table 33. Observed ringed seal densities during spring aerial surveys in the central Beaufort Sea, 1996–2002.

Survey Year	Observed Density (seals/km ²)	Source
1996	0.81	Frost et al. (2004)
1997	0.73 ^a	Frost et al. (2004)
1997	0.43 ^b	Moulton et al. (2005) ^c
1998	0.64 ^a	Frost et al. (2004)
1998	0.39 ^b	Moulton et al. (2005) ^c
1999	0.87 ^a	Frost et al. (2004)
1999	0.63 ^b	Moulton et al. (2005) ^c
2000	0.47	Moulton et al. (2005) ^c
2001	0.54	Moulton et al. (2005) ^c
2002	0.83	Moulton et al. (2005) ^c
Average	0.634	
^a Frost et al. (2004) recalculated their observed densities for 1997–1999 to compare their estimates with Moulton et al. (2005). These recalculated densities, for the same survey area as Moulton et al. (2005), are used here, except for the year 1996. The surveys by Frost et al. (2004) were flown northward beginning at the approximate 3-m isobath. ^b Areas with water depth less than 3 m excluded. ^c Also reported for 1997–2001 by Moulton et al. (2002) in Richardson and Williams (2002) and for 2002 by Moulton et al. (2003) in Richardson and Williams (2003).		

Feeding and Prey Selection

Arctic ringed seals typically lose a significant proportion of their blubber mass in late winter to early summer and then replenish their blubber reserves in late summer or fall into winter (Ryg et al. 1990; Young and Ferguson 2013; Quakenbush et al. 2020). 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. Diet studies indicate that ringed seals in Alaska eat a wide variety of vertebrate and invertebrate prey species, but certain prey species, such as Arctic cod, saffron cod, shrimps, and amphipods occupy a prominent role in their diet (Dehn et al. 2007; Quakenbush et al. 2011; Crawford et al. 2015; Quakenbush et al. 2020).

Hearing and Vocalizations

The behavioral context of ringed seal underwater vocalizations is not well known, but they are thought to play a role in the seals' reproductive behavior (Stirling 1983; Kelly 2022). NMFS defines the underwater and in-air generalized hearing ranges for phocids (including ringed seals) as 40 Hz to 90 kHz and 42 Hz to 52 kHz, respectively (NMFS 2024b). A study on the hearing of

captive ringed seals suggests that the species has the ability to detect signals surrounded by background noise (Sills et al. 2015).

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.

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 (2021) 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). Along the marine transit route for the proposed project (Aleutian Islands, Bering Sea, Chukchi sea, and Beaufort Sea), we consider Hawaii DPS individuals to comprise 90.9 percent of the humpback whales present, Mexico DPS individuals to comprise 7.1 percent, and the Western North Pacific DPS individuals to comprise 2 percent (Table 34). In Cook Inlet, which is considered part of the GOA summer feeding area, we consider Hawaii DPS individuals to comprise 89 percent of the humpback whales present, Mexico DPS individuals to comprise 10.6 percent, and Western North Pacific DPS individuals to comprise 0.3 percent (Table 34).

The Hawaii DPS is not listed under the ESA, and is estimated at 11,540 animals (CV = 0.04), with an estimated annual growth rate of between 5.5 and 6.0 percent (Wade 2021). The threatened Mexico DPS is comprised of approximately 2,913 animals (CV = 0.07) (Wade 2021), with an unknown but likely declining population trend (81 FR 62260; September 8, 2016). The endangered Western North Pacific DPS is estimated at 1,084 animals (CV = 0.09) (Wade 2021) and the population trend for this DPS is unknown. Humpback whales in the Western North Pacific DPS 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 34. Percent probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (rows). Adapted from (Wade 2021).

Summer Feeding Areas	North Pacific Distinct Population Segments (DPS) (percent probability)			
	Western North Pacific DPS (endangered) ^a	Hawaii DPS (not listed)	Mexico DPS (threatened)	Central America DPS (endangered) ^a
Kamchatka	90.9	8.8	0.3	0
Aleutian Islands, Bering Sea, Chukchi Sea, and Beaufort Sea	2.0	91.0	7.1	0
Gulf of Alaska	0.3	89.0	10.6	0
Southeast Alaska and Northern BC	0	97.6	2.4	0
Southern BC and WA	0	68.8	25.4	5.9
OR and CA	0	0	57.7	42.3

^a Note that in the past iteration of this guidance, upper confidence intervals were used for endangered DPSs. However, the revised estimates do not have associated coefficients of variation to cite. Therefore, the point estimate is being used for each probability of occurrence.

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 (Brower et al. 2022a; Wild et al. 2023).

Humpback whales occur throughout the central and western GOA 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 GOA (Wade 2021).

Humpback whales are found throughout the Aleutians Islands (Zerbini et al. 2006) and much of the Bering Sea (Wade 2021), and they occur as far north as the northeastern Chukchi Sea and western Beaufort Sea near Utqiagvik during summer (Stafford et al. 2023). They are consistently concentrated seasonally in coastal waters north of Unimak Pass and in the eastern Aleutian Islands, but densities decline in the western Aleutians (Wade 2021).

Occurrence in the Action Area¹¹

Marine Transit Routes

We expect that humpback whales may be present along the Bering Sea, Chukchi Sea, and western Beaufort Sea portion of the proposed marine transit route between Dutch Harbor and Prudhoe Bay. The route passes through a BIA in the Aleutian Islands around Unalaska and extending into the Bering Sea (considered active May–January) where humpback whales feed in high densities (Figure 38) (Brower et al. 2022a). Several watch list areas for humpback whale feeding were also identified in the Bering Sea region where information was insufficient to confidently delineate BIAs (Figure 38) (Brower et al. 2022a). Additionally, the route overlaps with a BIA identified in the southern Chukchi Sea for humpback whale feeding during July through September (Figure 39) (Clarke et al. 2023).

Relatively high densities of humpback whales occur throughout much of Southeast Alaska and northern British Columbia, particularly during the summer months. Most whales in this area are from the Hawaii DPS (98 percent) with a small number from the Mexico DPS (2 percent; Wade 2021). Although migration timing varies among individuals, most whales depart for Hawaii or Mexico in fall or winter and begin returning to Southeast Alaska in spring, with continued returns through the summer and a peak occurrence during late summer to early fall. However, there are significant overlaps in departures and returns (Baker et al. 1985; Straley 1990).

In the Gulf of Alaska, humpback whales are from the Hawaii DPS (89 percent), Mexico DPS (11 percent), and Western North Pacific DPS (1 percent; Wade 2021). Humpbacks occur through the central and western Gulf of Alaska from Prince William Sound to the Shumagin Islands. Seasonal concentrations are found in the 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 185 km offshore in the western Gulf of Alaska (Rone et al. 2017; Wade 2021).

Based on the available information regarding the species' distribution, we also expect that humpback whales may overlap with vessel traffic associated with the proposed construction and operation of Alaska LNG facilities in Cook Inlet.

¹¹ We do not anticipate humpback whales to be present in the portion of the action area associated with construction in Prudhoe Bay.

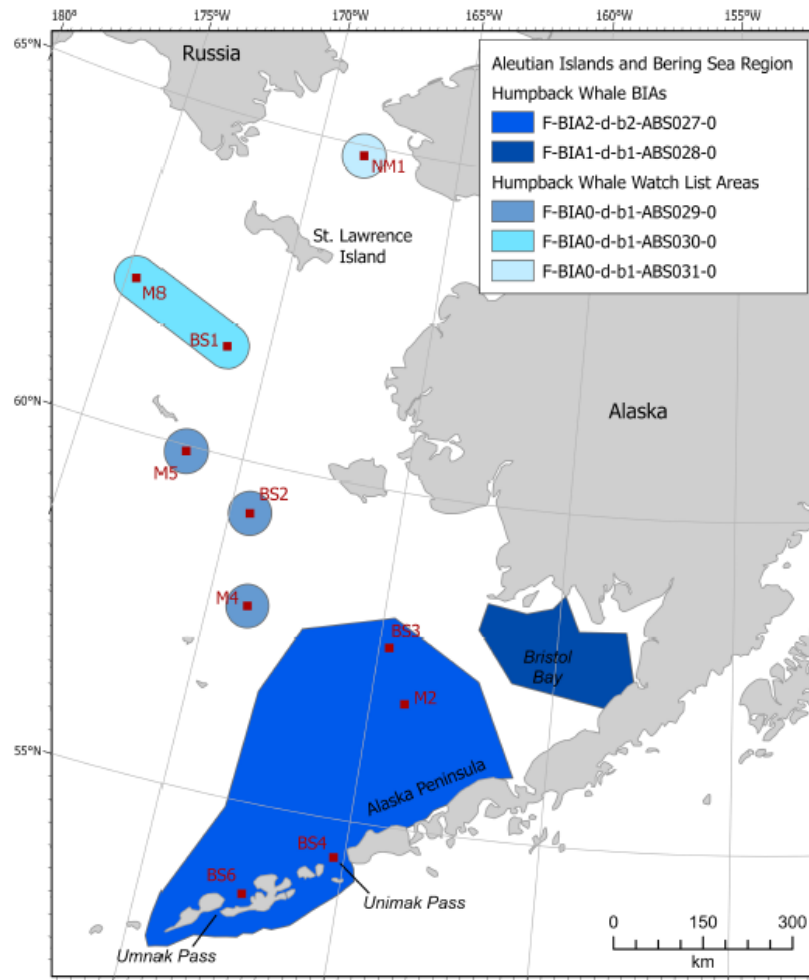


Figure 38. Humpback whale feeding BIA identified in the Aleutian Islands and Bering Sea region; watch list areas for humpback whale feeding are also shown (Brower et al. 2022a, Figure 5).

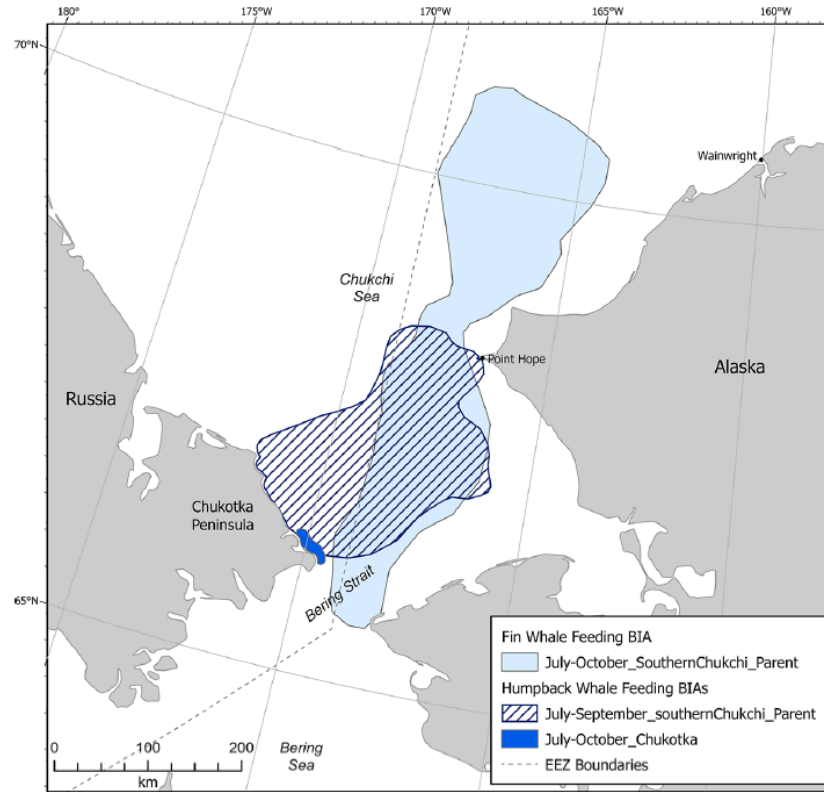


Figure 39. Humpback whale and fin whale feeding BIA identified in the Chukchi Sea based on a combination of aerial surveys, vessel-based opportunistic sightings, and acoustic recordings (Clarke et al. 2023, Figure 11).

Cook Inlet

Humpback whales have been observed throughout Cook Inlet; however, they are primarily seen in lower Cook Inlet. During the NMFS aerial beluga whale surveys between 1993 and 2022 in June, there were 97 sightings of an estimated 211 individual humpback whales (Figure 39 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. 2005; Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b; Shelden et al. 2022). Additionally, during the 2013 marine mammal monitoring program at Cosmopolitan State well site #A-1 (in the eastern part of lower Cook Inlet toward Anchor Point), marine mammal observers reported 29 sightings of 48 humpback whales (Owl Ridge 2014); and during the 2014 Apache seismic surveys in Cook Inlet (north and east of the action area), marine mammal observers reported six individual humpback whales (Lomac-MacNair et al. 2014). More recently, in the fall of 2019 (mid-September to mid-October) during Hilcorp's seismic survey in lower Cook Inlet, 14 sightings of 38 humpback whales were recorded (Fairweather Science 2020). Of the BIAs identified by Wild et al. (2023) for humpback whale feeding in the GOA, the BIA extending from near the mouth of Cook Inlet to the Semidi Islands, southwest of Kodiak Island, (active May–September) is closest to the proposed construction activities in Cook Inlet (Figure 40).

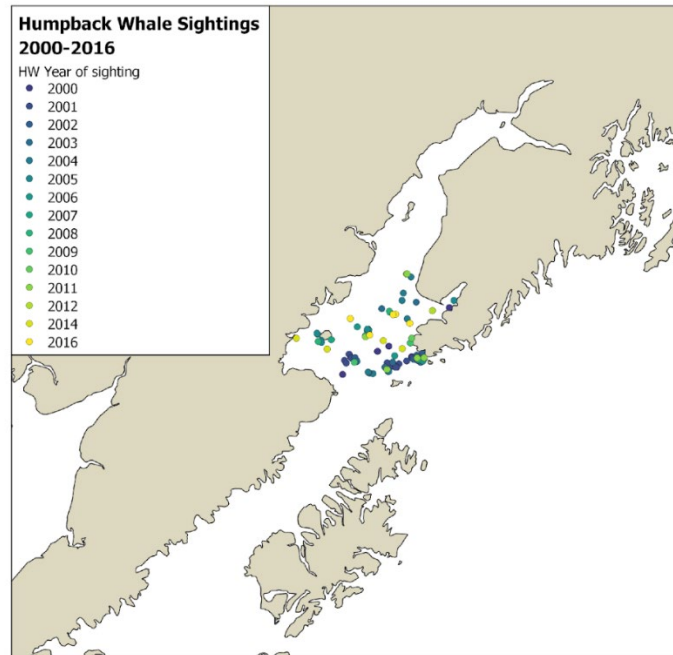


Figure 40. Humpback whale observations during aerial surveys for belugas in Cook Inlet, 2000–2016 (Rugh et al. 2005; Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b).



Figure 41. Humpback whale feeding BIA (green hatched area) around the Kodiak Archipelago, near the mouth of Cook Inlet (data from Wild et al. 2023).

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 2017a). 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). 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. 2018b). Additionally, one humpback was observed in July 2022 during transitional dredging at the POA (61 North Environmental 2022b). Finally, deceased humpbacks were reported in upper Cook Inlet in 2015, 2017, and 2019 (NMFS unpublished data).

For this action, the density of humpback whales in the Cook Inlet portion of the action area was estimated at 0.00185 whales/km² using sightings based on the results from NMFS aerial surveys conducted for beluga whales in June between 2000 and 2022 (Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b; Shelden and Wade 2019; Shelden et al. 2022). 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. As mentioned above, of these whales, 1 percent are estimated to be from the Western North Pacific DPS, and 11 percent from the Mexico DPS (the remaining 89 percent being from the non-listed Hawaii DPS).

Table 35. Humpback whale sightings, including group size, during aerial surveys for belugas in Cook Inlet, 2000–2016.

Year ^a	Month	No. Sightings	No. Whales	Location (No. whales)
2022	June	5	7	W. of Kachemak Bay (6); W. of Ninilchik (1)
2021	June	0	0	
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 (4)
2014	June	4	11	W. of Koyuktolik Island (4); Bruin Bay (1); 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	1	2	N. of Koyuktolik Bay (2)
2009	June	2	5	N.W. of Barren Island (3); N. of Koyuktolik Bay (2)
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		97	211	

^a Source: Shelden et al. (2022), 2021–2022, Shelden and Wade (2019), 2018, Shelden et al. (2017b), 2016, Shelden et al. (2015a), 2014; and Shelden et al. (2013), 2000–2012.

Feeding and Prey Selection

Humpback whales in the North Pacific forage in the coastal and inland waters along California, north to the GOA and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomilin 1967; Johnson and Wolman 1984).

In the waters off Alaska, including in the GOA, around the eastern Aleutian Islands, and in the eastern Bering Sea, humpback whales feed on a variety of prey species including euphausiids and small fishes such as Pacific herring, Pacific mackerel (*Scomber japonicus*), sand lance, juvenile walleye pollock, capelin, eulachon (*Thaleichthys pacificus*), Atka mackerel (*Pleurogrammus monopterygius*), Pacific cod (*Gadus macrocephalus*), saffron cod, Arctic cod, juvenile salmon, and rockfish (*Sebastes* spp.) (NMFS 2020b).

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. 1982a).

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 and Vocalizations

Humpback whales produce a wide variety of sounds (especially animals in mating groups) ranging from about 20 Hz to over 10 kHz. During the breeding season males sing high-intensity, long, complex songs, with fundamental frequencies in the 20 Hz to 5 kHz range (Payne 1970; Winn et al. 1970; Thompson et al. 1986). Humpback whales also produce a suite of non-song vocalizations (calls) of short duration, the majority of which are less than 3 kHz (e.g., Thompson et al. 1986; Stimpert et al. 2011; Fournet et al. 2015).

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 (Ketten 1997; Houser et al. 2001), 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 (Ketten 1997; Au et al. 2006). These values fall within the NMFS (NMFS 2024b) generalized low-frequency cetacean hearing range of 7 Hz to 36 kHz.

4.3.5 Cook Inlet Beluga Whale

Status and Population Structure

Beluga whales inhabiting Cook Inlet are one of five distinct stocks found in Alaska (Young et al. 2024a). 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. 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 current abundance estimate for the Cook Inlet beluga whale population is 331 whales (95 percent probability interval of 290 to 386), and is based on aerial surveys conducted in June 2022 (Goetz et al. 2023). A declining trend of 2.3 percent per year was found to occur from 2008 to 2018 (Shelden and Wade 2019). However, with the addition of survey data from 2021 and 2022, the trend in the updated time-series suggests the population is stable and may be slightly increasing (Figure 42) (Goetz et al. 2023).

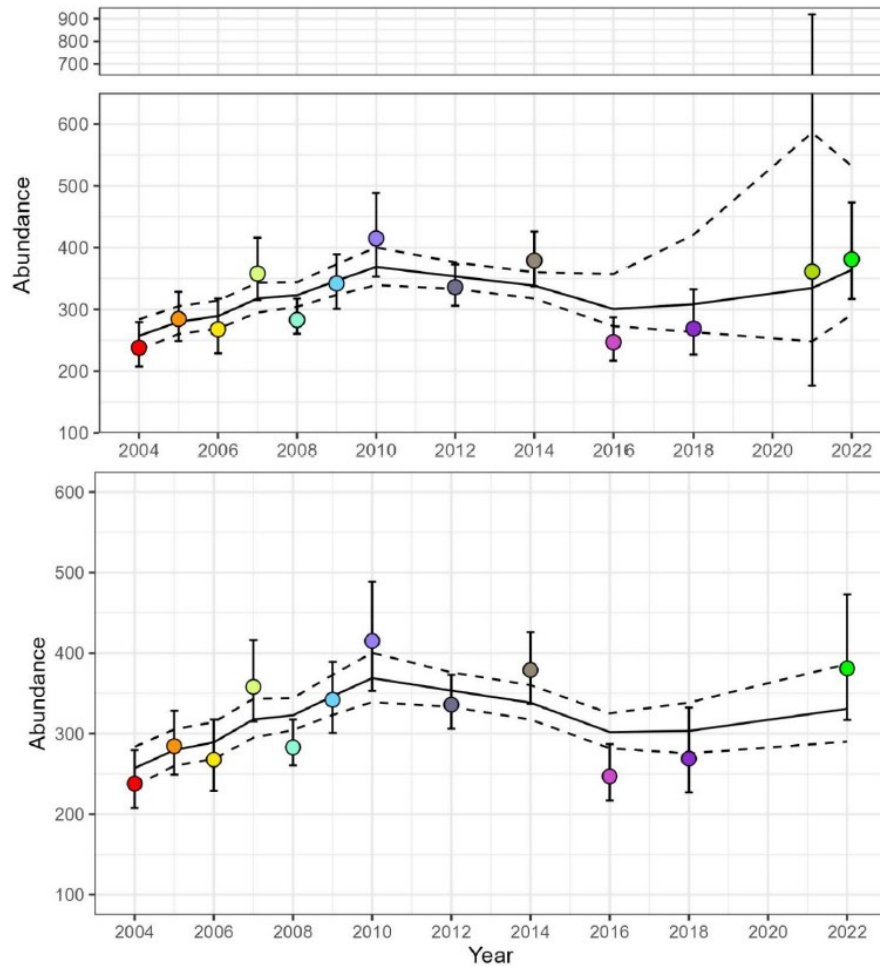


Figure 42. Cook Inlet beluga whale annual abundance estimates (circles) and 95 percent probability intervals (error bars) for the survey period 2004–2024. The moving average is also plotted (solid line), with 95 percent probability intervals (dashed lines). The top panel includes data from 2021. (Goetz et al. 2023).

Annual mortality, estimated from stranding deaths relative to the population size, averaged 2.2 percent between 2005 to 2017 (McGuire et al. 2021). This is a minimum estimate due to the challenges associated with detecting stranded animals in Cook Inlet. McGuire et al. (2021) estimated that the mean number of reported beluga carcasses represents less than one third of the total number of dead belugas each year.

The Cook Inlet Beluga Recovery Plan (NMFS 2016d) addresses ten principal threats to the population. Table 36 provides a summary of these threats and their potential impact on Cook Inlet beluga recovery. 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.

Table 36. Summary of threats assessment for Cook Inlet beluga whales (NMFS 2016d).

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

The Alaska LNG project activities in upper Cook Inlet (Figure 8) overlap heavily with the distribution of Cook Inlet beluga whales. Although they remain year-round in Cook Inlet, Cook Inlet belugas demonstrate seasonal movements within the inlet. In general, during the summer and fall, beluga whales occur in shallow coastal waters and are concentrated near the Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay, and near Fire Island in the upper inlet (Shelden et al. 2015b; Castellote et al. 2020; McGuire et al. 2020b), and the Kenai River Delta in the lower inlet (McGuire et al. 2020b; Kumar et al. 2024). During the winter, they are more dispersed, occurring 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. While ice formation in the upper inlet was once thought to restrict beluga's access to nearshore habitat (Ezer et al. 2013), tagging data, acoustic studies, visual surveys, and opportunistic sightings indicate that Cook Inlet belugas continue to occur in the upper inlet throughout the winter months, in particular the coastal areas from Trading Bay to Little Susitna River, with foraging behavior detected in lower Knik Arm and Chickaloon Bay, and also detected in several areas of the lower inlet such as the Kenai River, Tuxedni Bay, Big River, and northwest Kalgin Island (Shelden et al. 2015b; Castellote et al. 2016; Shelden et al. 2018; Castellote et al. 2020; Castellote et al. 2021; Castellote et al. 2023).

Distribution data, including data from aerial surveys and acoustic monitoring, indicate that the beluga range in Cook Inlet has contracted markedly since the 1990s (Table 43) (Shelden et al. 2015b; Shelden and Wade 2019). This distributional shift and range contraction coincided with the decline in abundance (Moore et al. 2000; NMFS 2008c; Goetz et al. 2012). Surveys in the 1970s showed belugas dispersing into the lower inlet by mid-summer; prior to the 1990s, whales used areas throughout the upper, mid, and lower inlet during the spring, summer, and fall (Huntington 2000; Rugh et al. 2000; NMFS 2008c; Rugh et al. 2010).

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. Between 2012 and 2021, groups of 200 or more individuals—almost the entire population—including adults, juveniles, and neonates, were observed in the Susitna River Delta area in all years except 2016 and 2021 (maximum group size in 2016 and 2021 was 148 and 15 animals, respectively) (McGuire et al. 2020b; McGuire et al. 2023). Acoustic monitors at the Little Susitna River recorded a peak in daily hours positive for beluga detection from late May to early June, and a large peak from July to August (Figure 44) (Castellote et al. 2016; Castellote et al. 2020). 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 45) (Castellote et al. 2016; Castellote et al. 2020). These peaks during summer appear to coincide with eulachon runs in May and June (Vincent-Lang and Queral 1984), and salmon runs from June to July (Brenner et al. 2019) (Castellote et al. 2021).

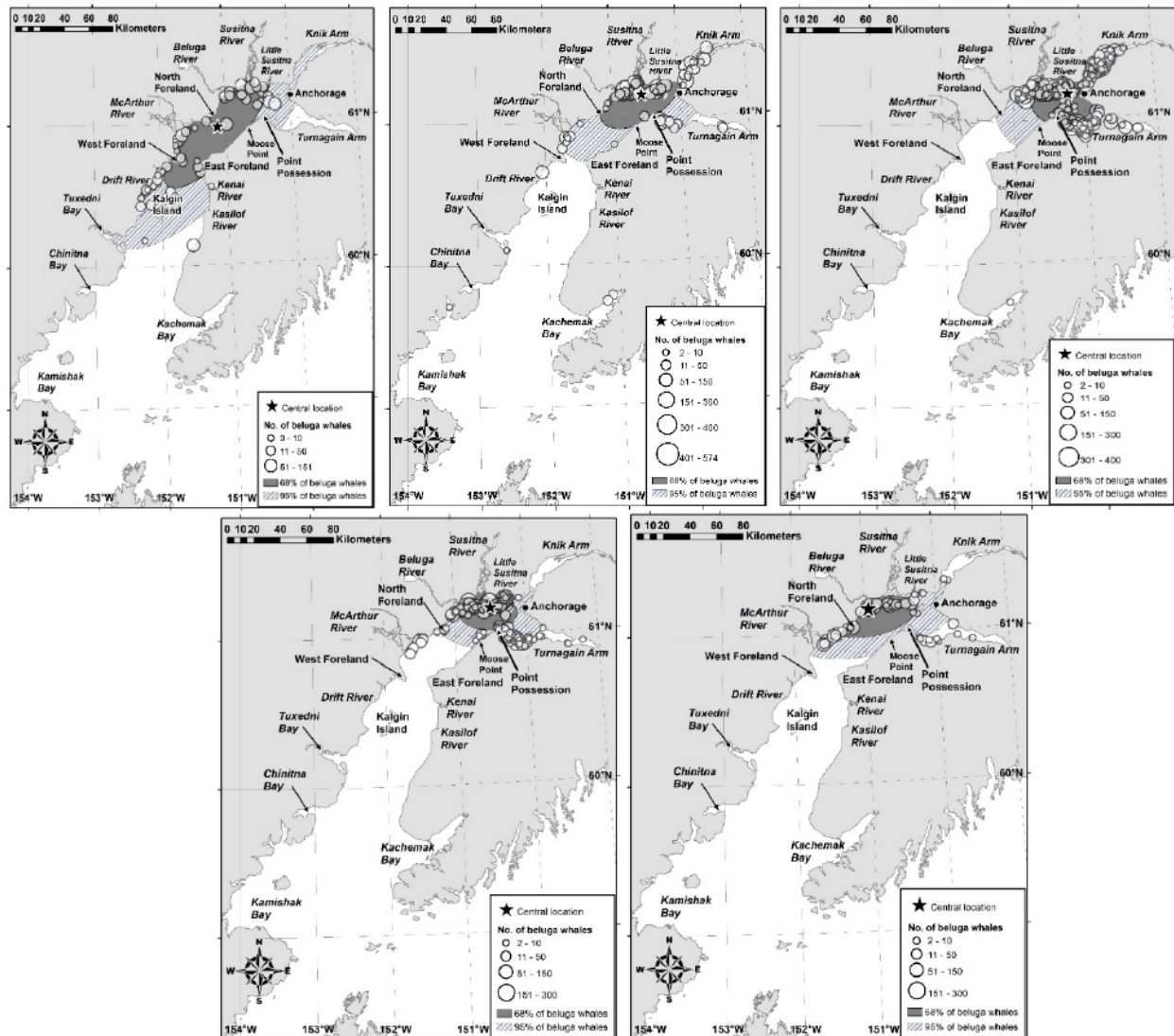


Figure 43. Areas occupied by beluga whales in Cook Inlet, Alaska, during systematic aerial surveys in 1978–1979 (top left), 1993–1997 (top middle), 1998–2008 (top right), 2009–2018 (bottom left), and 2021–2022 (bottom right). Distribution of belugas around each central location (star symbol) for each period was calculated at 1 standard deviation (encompassing ~68% of whales; shaded area) and 2 standard deviations (encompassing ~95 percent of whales; hatched area) (Goetz et al. 2023, Figure 12).

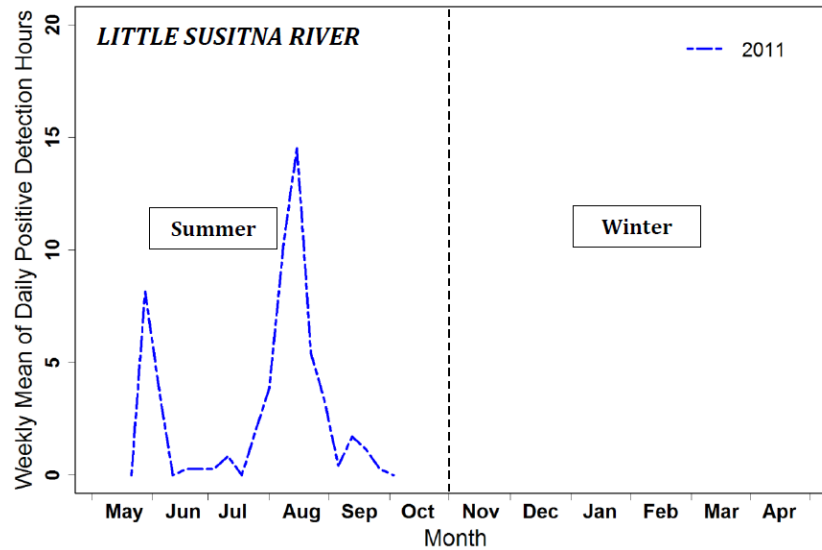


Figure 44. Weekly mean of daily beluga detection positive hours by month at Little Susitna River, Cook Inlet, Alaska, 2011 (Castellote et al. 2016, Figure 3D).

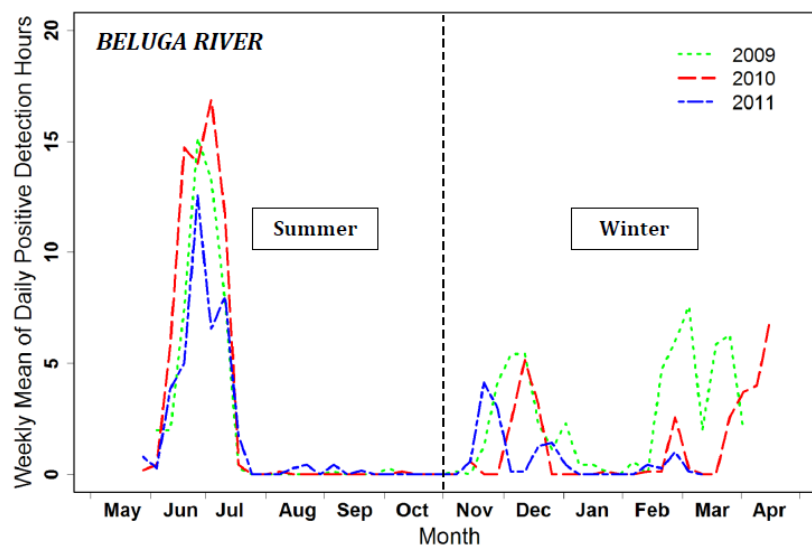


Figure 45. Weekly mean of daily beluga detection positive hours by month at Beluga River, Cook Inlet, Alaska, 2009–2011 (Castellote et al. 2016, Figure 3E).

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 habitat for Cook Inlet beluga whales in winter, early spring, and fall (Castellote et al. 2023; NMFS unpublished data). Aerial distribution surveys conducted during spring (March–April) and fall (September/October–November/December) in 2018 through 2021 documented belugas in the Kenai and Kasilof rivers, Tuxedni Bay, and near Kalgin Island, as well as in the upper inlet (Figure 46) (NMFS 2022).

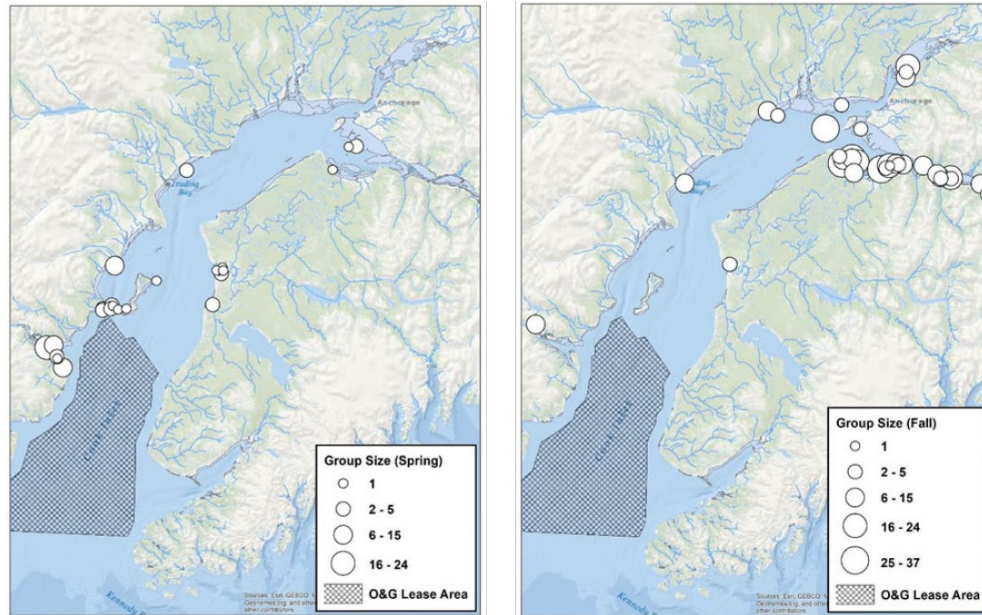


Figure 46. Beluga whale sighting locations (white circles) in Cook Inlet, Alaska, during aerial surveys conducted in spring (March–April) and fall (September/October–November/December), 2018–2021 (NMFS 2022, Figure 13).

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).¹² 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 47) (Castellote et al. 2016; Castellote et al. 2020; Kumar et al. 2024).

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. 2015a; 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). Beluga sightings were also documented during three beluga monitoring sessions at the Kasilof River in later April of 2022 (Kumar et al. 2024).¹³ Between May and November of 2021 and 2022, passive acoustic monitoring detected no beluga sounds in the Kasilof River; however, they were recorded off the river mouth in December through March of those years (Kumar et al. 2024).

¹² Alaska beluga monitoring program, <https://akbmp.org/beluga-observation-log/>. Accessed September 2025.

¹³ See footnote 12.

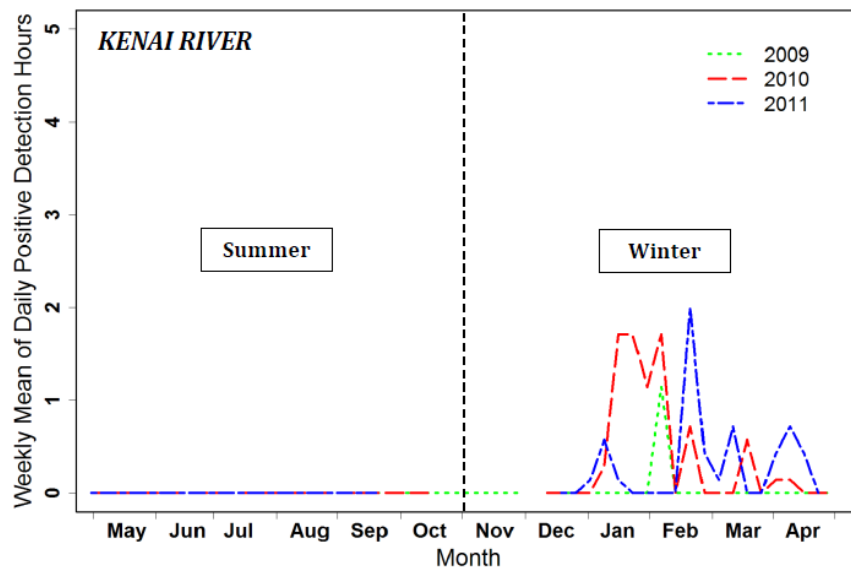


Figure 47. Weekly mean of daily beluga detection positive hours by month at the Kenai River, Cook Inlet, Alaska, 2009–2011 (Castellote et al. 2016, Figure 4F).

Belugas may be present in Tuxedni Bay (Figure 48) throughout the year, where peaks in acoustic detections were recorded in January and especially in March (Shelden et al. 2015a; Castellote et al. 2016). Belugas were seen in March 2018 and 2019 in Tuxedni Bay during NMFS winter distribution aerial surveys (Figure 46; 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.

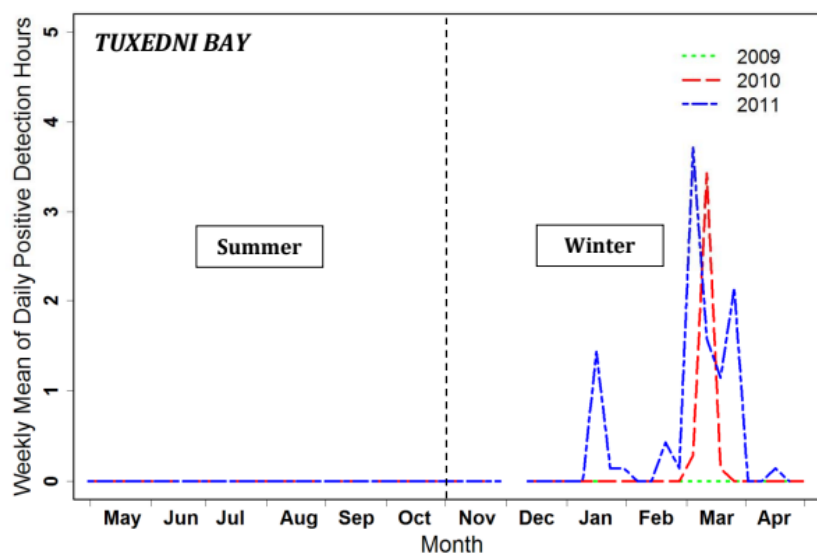


Figure 48. Weekly mean of daily beluga detection positive hours by month in Tuxedni Bay, Cook Inlet, Alaska, 2009–2011 (Castellote et al. 2016, Figure 4G).

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. January 19, 2016). Hilcorp reported 143 sightings of beluga whales during May through August while conducting pipeline work in upper Cook Inlet in an area near the proposed pipeline crossing (Sitkiewicz et al. 2018b).

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 49). 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 49). As detailed below in Section 6.3.1.1 of this opinion, using the resulting grid densities, average densities were calculated for three regions applicable to the proposed project locations: 0.00016 whales/km² for marine terminal construction, 0.01070 whales/km² for mainline crossing construction, and 0.03680 whales/km² for mainline MOF construction.

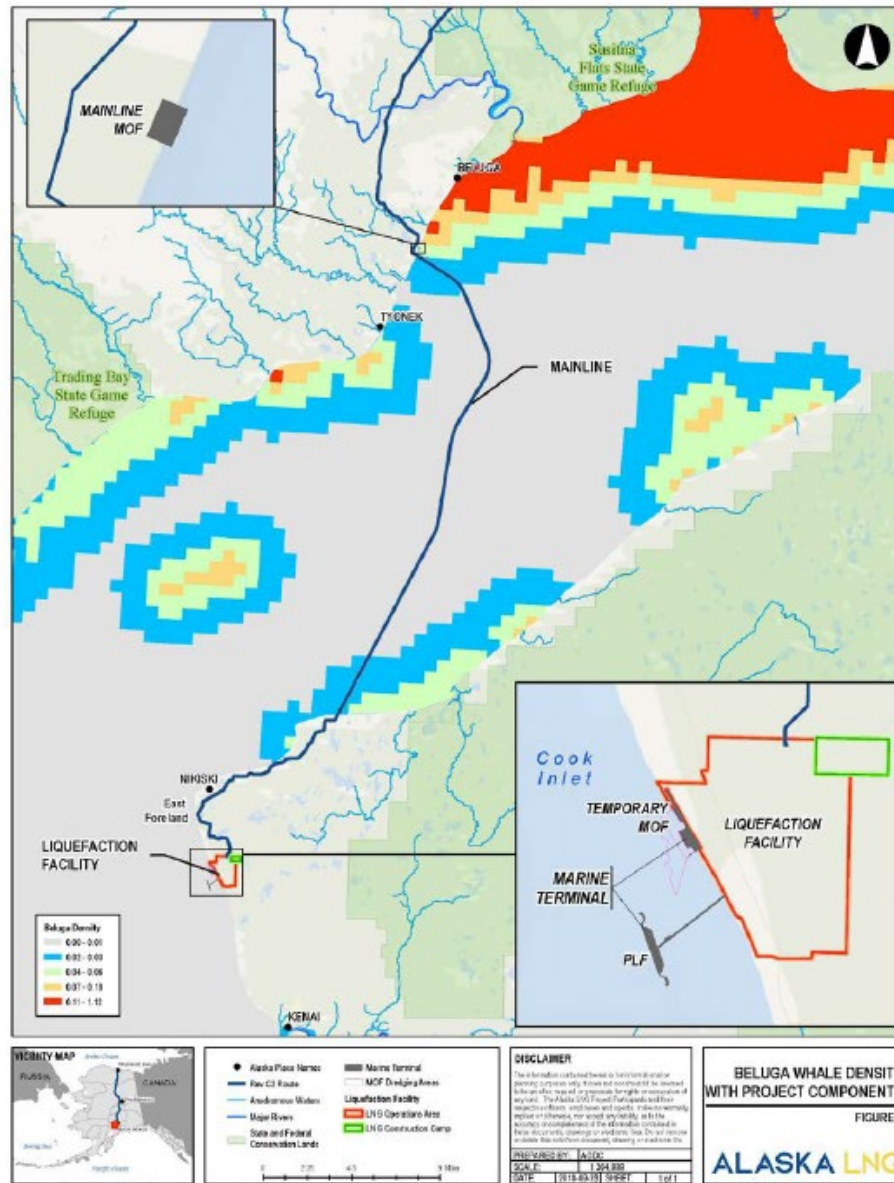


Figure 49. Beluga whale density during the summer modeled by Goetz et al. (2012) and the Alaska LNG project components in Cook Inlet, Alaska.

Reproduction

Probable mating behavior was observed in April and May of 2014 in Trading Bay (Lomac-MacNair et al. 2016). Conception is predicted to peak from March through May, based on analysis of stranded neonates, fetuses, and calves of the year; however, conception can occur over a wide period of up to 7 months (Shelden et al. 2020). Neonates have been observed between early July and mid-October, and three possible beluga births were observed between June and September (July 20, 2015, and July 19, 2016, in the Susitna River Delta; and September 13, 2016 in Turnagain Arm) (McGuire et al. 2020a). Most calving in Cook Inlet is assumed to occur from mid-May to mid-July (Calkins 1989), but calving could occur through the entire ice-

free period from April through November (Shelden et al. 2020). 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).

Feeding and Prey Selection

Cook Inlet beluga whales have diverse diets (Quakenbush et al. 2015; Nelson et al. 2018), foraging on fish and benthos, often at river mouths. Primary prey species consist of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole. Belugas seasonally shift their distribution within Cook Inlet in relation to the timing of fish runs and seasonal changes in ice and currents (NMFS 2016d).

The seasonal availability of energy-rich prey (Abookire and Piatt 2005; Litzow et al. 2006) is very important to the energetics of belugas. Cook Inlet belugas have much lower fat reserves in the spring than after feeding on abundant eulachon and salmon in the spring and summer (NMFS 2008e; Saupe et al. 2014a). Eating fatty prey and building up fat reserves in the spring and summer may allow beluga whales to sustain themselves during periods of reduced prey availability in winter or when metabolic needs are higher (NMFS 2008c).

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). Belugas produce a variety of audible whistles, squeals, clucks, mews, chirps, trills, and bell-like tones (Castellote et al. 2014). At the higher frequency 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. 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; Tyack 1999; Stoeger et al. 2012).

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; Johnson et al. 1989; Klishin et al. 2000; Ridgway et al. 2001; Finneran et al. 2002a; Finneran et al. 2002b; Finneran et al. 2005; Mooney et al. 2008). In the first report of hearing ranges of belugas in the wild, Castellote et al. (2014) documented 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 and Finneran 2006; Houser et al. 2018). Most of these studies measured beluga hearing in very quiet conditions. Tidal currents in Cook Inlet regularly produce ambient sound levels well above 100 dB (Lammers et al. 2013), and beluga signal intensity can change with location and background noise levels (Au et al. 1985). NMFS categorizes Cook Inlet beluga whales in the high-frequency

cetaceans functional hearing group, with a generalized hearing range of between 150 Hz and 160 kHz (NMFS 2024b).

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). A recovery plan for the fin whale was published on July 30, 2010 (NMFS 2010c). Critical habitat has not been designated for this species.

NMFS recognizes three stocks of fin whales in U.S. Pacific waters: (1) Northeast Pacific (Alaska), (2) California/Washington/Oregon, and (3) Hawaii (Young et al. 2024a). There are no reliable estimates of current or historical abundances for the entire Northeast Pacific fin whale stock. Many of the studies that provide information on the distribution, occurrence, and/or abundance estimates for areas within the range of the Northeast Pacific stock are over a decade or more old. A dedicated line-transect survey of the offshore waters of the GOA and in 2013 provided an abundance estimate of 3,168 fin whales (Rone et al. 2017) and a minimum population estimate of 2,554 whales was derived from this provisional estimate (Young et al. 2024a). This is an underestimate for the entire stock as it is based on surveys that covered a small portion of their range (Young et al. 2024a).

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 GOA, Bering Sea/Aleutian Islands, and as far north as the northern Chukchi Sea (Young et al. 2024a). Fin whales are typically found in deep water (Matsuoka et al. 2013; Rone et al. 2017) away from the immediate coast (Clarke et al. 2020).

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; Watkins et al. 2000; Moore et al. 2006; Stafford et al. 2007; Širović et al. 2013; Soule and Wilcock 2013; Archer et al. 2020). These studies documented high levels of fin whale call rates along the U.S. Pacific coast 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 GOA 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).

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 2010c). Fin whales in Cook Inlet have only been observed as individuals or in small groups.

Occurrence in the Action Area¹⁴

Marine Transit Routes

We expect that fin whales may be present along the Bering Sea and Chukchi Sea portion of the proposed marine transit route between Dutch Harbor and Prudhoe Bay. 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 (Young et al. 2024a). Brower et al. (2022a) identified BIAs for fin whale feeding in the Bering Sea region, one of which (active during May–February) overlaps with the marine transit route (Figure 50). Several watch list areas were also identified by Brower et al. (2022a) in this region (three for feeding and two for migration) where information was insufficient to confidently delineate BIAs (Figure 50). In addition, the transit route crosses through a BIA for fin whale feeding during July through October in the southern Chukchi Sea (Figure 39 above) (Clarke et al. 2023).

Based on the available information regarding the species' distribution, we also expect that fin whales may overlap with vessel traffic associated with the proposed construction and operation of Alaska LNG facilities in Cook Inlet.

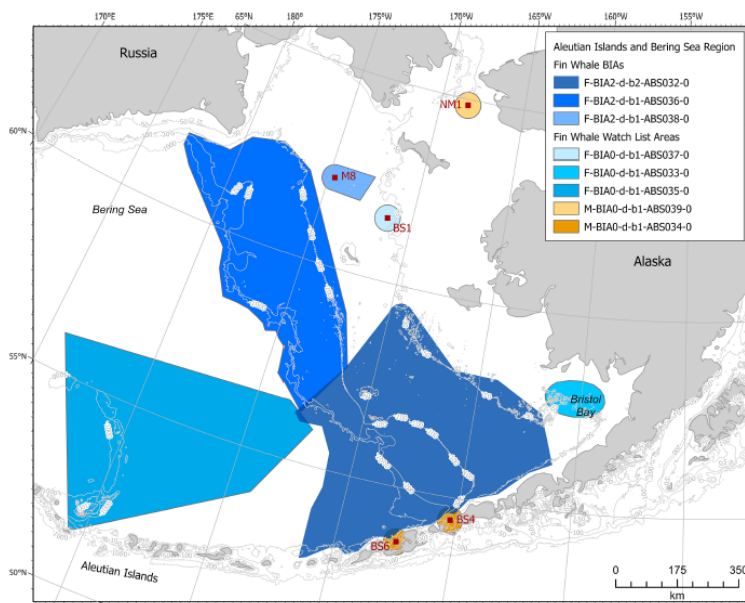


Figure 50. Fin whale feeding BIAs identified in the Bering Sea region based on aerial- and vessel-based surveys and acoustic recordings; watch list areas for fin whale feeding (F) and migration (M) are also shown (Brower et al. 2022a, Figure 6).

¹⁴ We do not anticipate fin whales to be present in the portion of the action area associated with construction in Prudhoe Bay.

Cook Inlet

Fin whales have rarely been documented in Cook Inlet and most reported sightings have occurred near the entrance of the inlet. During the NMFS aerial beluga whale surveys from 2000 through 2022 in June (no fin whales were seen during surveys conducted in 2000, 2002, 2006–2013, or 2018–2022), 10 sightings of approximately 26 individual fin whales were documented in lower Cook Inlet (Figure 51) (Rugh et al. 2005; Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b; Shelden and Wade 2019; Shelden et al. 2022). In the fall of 2019 (mid-September to mid-October) during Hilcorp’s seismic survey in lower Cook Inlet, 8 sightings of 23 fin whales were documented, suggesting greater numbers may use the area in the fall (Fairweather Science 2020).

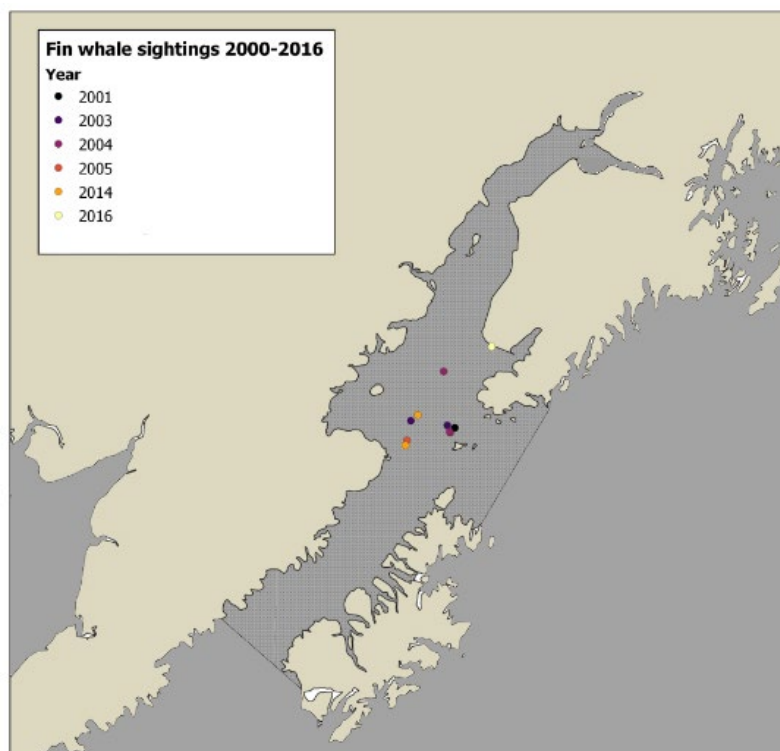


Figure 51. Fin whale sightings during aerial surveys for belugas conducted between 2000 and 2022 (no fin whales were seen in 2000, 2002, 2006–2013, or 2018–2022) (Rugh et al. 2005; Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b; Shelden and Wade 2019; Shelden et al. 2022).

Wild et al. (2023) identified a BIA for fin whale feeding (active June–September) in the GOA that extends from near the mouth of Cook Inlet to the Semidi Islands, south of Kodiak Island (Figure 52).

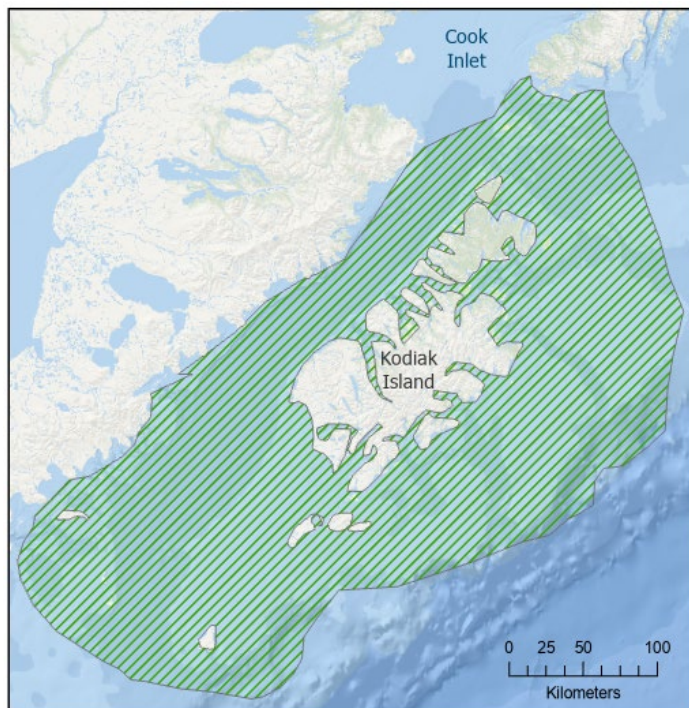


Figure 52. Fin whale feeding BIA identified around Kodiak Island based on aerial and vessel-based surveys and acoustic detections (data from Wild et al. 2023).

Fin whales occur too rarely in the portion of the action area in Cook Inlet to support development of density estimates, so we do not include density estimates. Marine mammal occurrence is used when density data is unavailable or not representative of the proposed project area.

Feeding and Prey Selection

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. 2006; Goldbogen et al. 2008). 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 (Nemoto 1970; Kawamura 1980b). 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).

Average dives of foraging fin whales are 98 m deep and 6.3 minutes long, compared to average non-foraging dives that are 59 m deep and 4.2 minutes long (Croll et al. 2001). Foraging dives deeper than 150 m have been documented (Panigada et al. 1999).

Hearing, Vocalizations, and Other Sensory Capabilities

Fin whales produce a variety of low-frequency sounds in the 10 Hz to 0.2 kHz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). 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). 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 have suggested there are geographic differences in the frequency, duration, and repetition of the pulses (Thompson et al. 1992).

The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that fin whales engage in long-distance communication (Payne and Webb 1971; Edds-Walton 1997). The sounds may also function for long-range echolocation of large-scale geographic targets such as seamounts, which may be used for orientation and navigation (Tyack 1999).

While there are no direct data on hearing in low-frequency cetaceans, NMFS identified the generalized hearing range of low-frequency cetaceans, including fin whales, at between 7 Hz and 36 kHz (NMFS 2024b). 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 is 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 was 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 2010b). Critical habitat has not been designated for this species.

The sperm whale is one of the most widely distributed marine mammals (Young et al. 2024a). 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. The North Pacific stock is the only stock occurring in Alaska waters (Young et al. 2024a).

Rice (1989) estimated the North Pacific stock of sperm whales at 1,260,000 animals prior to exploitation, and 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 (Young et al. 2024a).

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 primarily found in

deep waters, and sightings of sperm whales in water less than 300 m (984 ft) are uncommon. Sperm whales are usually found far offshore, except in cases where the shelf break or submarine canyons occur close to land (Mizroch and Rice 2013).

Sperm whales exhibit latitudinal sex segregation; all age classes and both sexes range throughout temperate and tropical regions, but only males move into higher latitudes to forage (NMFS 2010b). During the summer, males are found in the GOA, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988; Mizroch and Rice 2013; Ivashchenko et al. 2014). Females and juveniles generally remain in tropical and temperate latitudes, ranging no further than 50–51°N in the southern GOA. Discovery Mark data from commercial whaling days indicate extensive movement of females into the GOA, western Aleutians, and Bering Sea occurred historically (NMFS 2010b; Mizroch and Rice 2013). Matrilineal groups are considered to rarely occur in Alaskan waters currently. However, contemporary studies document the presence of female social groups in the GOA and Aleutian Islands (Fearnbach et al. 2012; Rone et al. 2017; Posdaljian et al. 2024), possibly representing a return to pre-whaling distributions of sperm whales.

Occurrence in the Action Area¹⁵

Marine Transit Routes

We expect that sperm whales may be present along the portion of proposed marine transit route between Dutch Harbor and Prudhoe Bay that overlaps with the species' distribution in the Bering Sea. Sperm whales have been frequently documented in the western Aleutian Islands, from Unalaska to the east out to the far islands. Surveys conducted by Forney and Brownell Jr. (1996) south of the eastern Aleutians found sperm whales in water depths of about 4,000 to 5,000 m over the Aleutian Abyssal Plain or north of the Aleutian Trench over deep basins. During 12 cetacean surveys in the summers of 2001–2007 and 2009–2010, 393 sightings of adult male sperm whales were made (Fearnbach et al. 2012). They were considered the most frequently sighted large cetacean in the coastal waters around the central and western Aleutian Islands (Young et al. 2024a). The transit route passes through two BIAs identified for sperm whale feeding in April through September around the Aleutian Islands and in May through September on the Bering Sea Slope (Figure 53) (Brower et al. 2022a). Based on the available information regarding the species' distribution, we also expect that sperm whales may overlap with vessel traffic elsewhere in waters off Alaska for vessel transits associated with the proposed construction and operation of Alaska LNG facilities in Cook Inlet. However, because of their preference for deeper waters far offshore, it is extremely unlikely that sperm whales would enter Cook Inlet near the proposed construction activities within Cook Inlet.

¹⁵ We do not anticipate sperm whales to be present in the portion of the action area associated with construction in Prudhoe Bay or Cook Inlet.

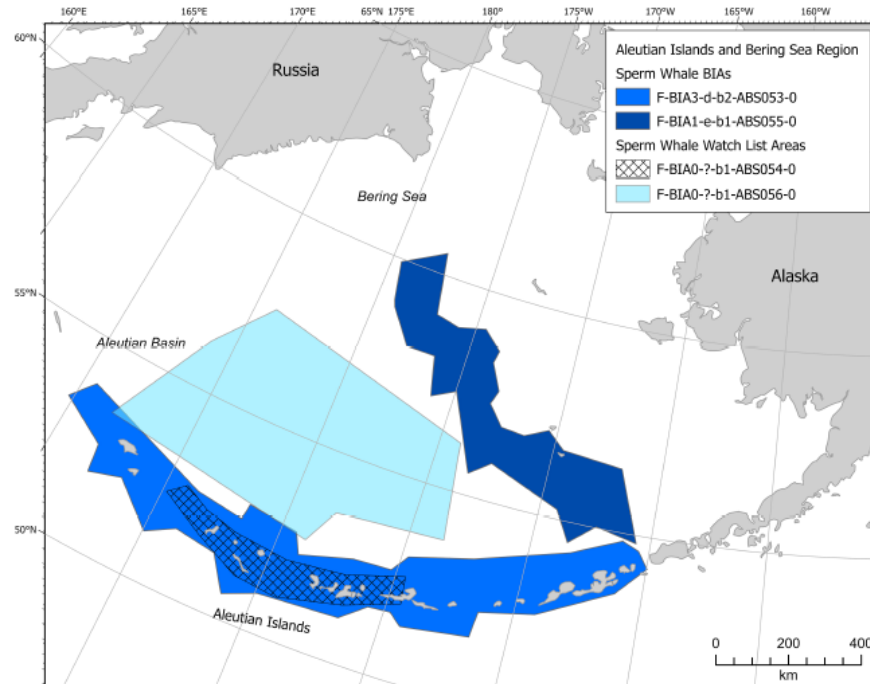


Figure 53. Sperm whale feeding BIAs identified in the Aleutian Islands and Bering Sea region; watch list areas for sperm whale feeding are also shown (Brower et al. 2022a).

Feeding and Prey Selection

Sperm whales are among the deepest marine mammal divers. Males have been known to dive 3,936 ft (2,000 m) while females dive to at least 3,280 ft (1,000 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 to 3.5 percent of their body weight in a day (Rice 1989).

Hearing, Vocalization, and Other Sensory Capabilities

Sperm whales produce a variety of loud, low-frequency clicks ranging from 0.1 to 20 kHz, with source levels up to 236 dB re 1μPa (Weilgart and Whitehead 1993; Goold and Jones 1995; Møhl et al. 2003; Weir and Goold 2007). These include patterned clicks (codas), which are used during social behavior and in interactions within social groups, usual clicks which are used during foraging/diving behavior, creaks (a series of rapid clicks) associated with prey detection, and slow clicks believed to be only produced by males in the context of mating (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Miller et al. 2004; Rendell and Whitehead 2004; Zimmer et al. 2005).

Sperm whales are odontocetes (toothed whales) and are considered high-frequency cetaceans with a generalized hearing range of 150 Hz to 160 kHz (NMFS 2024b). The only direct measurement of hearing available was from a young stranded individual from which auditory evoked potentials were recorded and indicated a hearing range of 2.5 to 60 kHz (Carder and Ridgway 1990). 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.

4.3.8 Western DPS Steller Sea Lion

Status and Population Structure

The Steller sea lion was listed as a threatened species under the ESA effective December 4, 1990 (55 FR 49204; November 26, 1990). Based on genetic, morphological, ecological, and population trend data, NMFS reclassified the Steller sea lion into two DPSs, effective June 4, 1997 (62 FR 24345; May 5, 1997). The Western DPS, comprised of animals born west of 144°W longitude, was listed as endangered due to persistent decline and lack of recovery (50 CFR 224.101), while the Eastern DPS remained listed as threatened. Effective December 4, 2013, the Eastern DPS was removed from the endangered species list (78 FR 66140, November 4, 2013). Steller sea lions west of 144°W longitude are almost exclusively from the Western DPS. Research has shown that some straying occurs and a small percentage of Steller sea lions east of 144°W longitude may be from the Western DPS (Hastings et al. 2020).

The Western stock of Steller sea lions decreased from 220,000 to 265,000 animals in the late 1970s to less than 50,000 in 2000 (Loughlin et al. 1984; Loughlin and York 2000; Burkanov and Loughlin 2005). The sharp drop in abundance of the Western stock observed in the 1980s was caused largely by a steep decline in juvenile survival and a smaller decline in adult survival (York 1994; Holmes and York 2003). The minimum population estimate for the U.S. portion of the range of Western DPS Steller sea lions in 2024 was 52,727 Steller sea lions (39,774 non-pups and 12,953 pups) (Sweeney et al. 2025). Non-pups and pups in this portion of the range increased 0.96 and 0.90 percent per year, respectively, between 2009 and 2024; however, there was high variability in the trends among regions (Sweeney et al. 2025).

Distribution

The range of the Western DPS Steller sea lions extends around the North Pacific rim from northern Japan, the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and Bering Sea, and along the coast of the GOA into northern Southeast Alaska (NMFS 2020a; Young et al. 2024a). Although Steller sea lions seasonally inhabit coastal waters of Japan in the winter, breeding rookeries outside of the U.S. are only located in Russia (Burkanov and Loughlin 2005). Most adult Steller sea lions occupy rookeries during the summer pupping and breeding season and exhibit a high level of site fidelity (Raum-Suryan et al. 2002; Hastings et al. 2017). Individual adult Steller sea lions move between rookeries and haul out sites regularly (Calkins and Pitcher 1982; Raum-Suryan et al. 2002; Raum-Suryan et al. 2004). Steller sea lions disperse widely after the breeding season (late May–July), likely to access seasonally important prey resources. During fall and winter many sea lions disperse from rookeries and increase use of haulouts, particularly on terrestrial sites but also on sea ice in the Bering Sea (Calkins 1998; Sinclair et al. 2019).

Steller sea lions are gregarious animals that often travel in large groups of up to 45 individuals (Keple 2002), and rafts of several hundred animals are often observed adjacent to haulouts.

Individual rookeries and haulouts may be comprised of hundreds of animals. At sea, groups usually consist of females and subadult males; individual adult males sometimes occur in such groups (Loughlin and Gelatt 2017).

Occurrence in the Action Area¹⁶

Marine Transit Routes

We expect that Western DPS Steller sea lions may be present along the Bering Sea/Bering Strait portion of the proposed marine transit route between Dutch Harbor and Prudhoe Bay. Steller sea lions are highly mobile, can range widely outside the breeding season, and they are common in and around Dutch Harbor (e.g., High Tide Environmental 2018), which is within a 37-km (20-nm) radius of a number of Western DPS Steller sea lion sites, and the Steller sea lion critical habitat aquatic zones around one major rookery and three major haulouts. Dutch Harbor is also located in, and the marine transit route crosses through, the Bogoslof special aquatic foraging area. In addition, the route passes through or near the Steller sea lion critical habitat aquatic zone around a major haulout on the east side of St. Lawrence Island. Aerial surveys for Steller sea lions conducted in 2012–2015 during fall to early winter (September–November) lions at St. Lawrence and Ingalik islands, recorded maximum counts each year ranging from 478 to 1,071 Steller sea lions (Sheffield and Jemison 2021).

Based on the available information regarding the species' distribution, we also expect that Steller sea lions may overlap with vessel traffic associated with the proposed construction and operation of Alaska LNG facilities in Cook Inlet.

Cook Inlet

NMFS aerial surveys for Cook Inlet beluga whales from 2000 to 2019 in June recorded 40 sightings of an estimated 752 Steller sea lions (no Steller sea lions were documented during the surveys conducted in 2020 and 2021); the majority were located south of the Forelands, where sightings of large aggregations of Steller sea lions occurred on terrestrial sites (e.g., Shaw Island) in the mouth of Cook Inlet (Rugh et al. 2005; Shelden et al. 2013; Shelden et al. 2015a; Shelden et al. 2017b; Shelden and Wade 2019). The nearest haulout, rookery, or other known Steller sea lion use site is at least 200 km from the construction sites in Cook Inlet (Figure 54).

Several monitoring programs have recorded Steller sea lion sightings (1–2 estimated animals per sighting) in Cook Inlet, including near the POA in 2020, 2021, 2022, and 2024 (61 North Environmental 2021a; 61 North Environmental 2022b; 61 North Environmental 2022a; 61 North Environmental 2022c; 61 North Environmental 2025) and to the south in upper Cook inlet in 2012 (3 sightings of 4 animals; Lomac-MacNair et al. 2013); in central Cook Inlet near Ladd Landing in 2018 (1 animal; Sitkiewicz et al. 2018b), and between the West and East Forelands, near Nikiski, in northern Trading Bay, and northeast of the North Foreland in 2015 (3 sightings of individuals; Kendall et al. 2015a); and in lower Cook Inlet outside Kachemak Bay in 2019 (3 sightings of individuals; (3 sightings of individuals; Fairweather Science 2020) and offshore

¹⁶ We do not anticipate Western DPS Steller sea lions to be present in the portion of the action area associated with construction in Prudhoe Bay.

about 16 km south of Ninilchik in 2013 (6 sightings of 7 animals; (Owl Ridge 2014). Additionally, at the end of July 2022, while conducting a waterfowl survey an estimated 25 Steller sea lions were observed hauled out at low tide in the Lewis River, on the west side of upper Cook Inlet. (K. Lindberg, personal communication, August 15, 2022, as cited in 90 FR 35775, July 29, 2025).

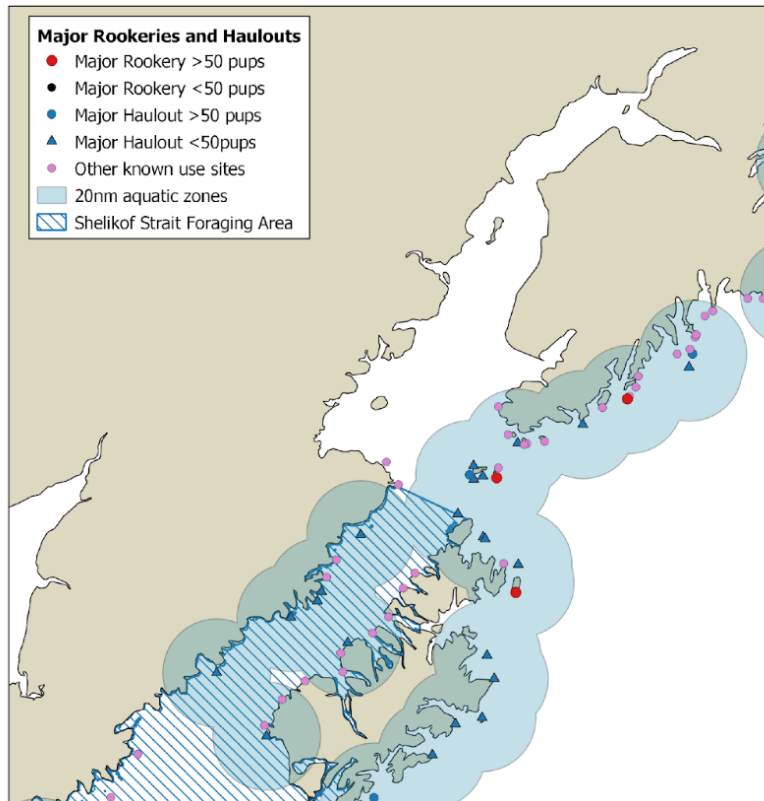


Figure 54. Steller sea lion sites in and near Cook Inlet.

Steller sea lions occur too rarely in the portion of the action area in Cook Inlet to support development of density estimates, so we do not include density estimates. Marine mammal occurrence is used when density data is unavailable or not representative of the proposed project area. For this action, we use observed marine mammal occurrence in Cook Inlet to estimate potential exposure to stressors within the action area. There has been increased monitoring of Steller sea lion presence in Cook Inlet in recent years, primarily associated with work at the Port of Alaska in 2020, 2021, 2022, and 2024. This monitoring indicates that more Steller sea lions are present in Cook Inlet than anticipated in prior analyses. The more recent sightings inform our conclusions about the potential for Steller sea lion presence in the action area in Cook Inlet and the exposure and take estimates presented in Sections 6 and 10.

Feeding and Prey Selection

The foraging strategy of Steller sea lions is strongly influenced by seasonality of sea lion reproductive activities on rookeries and the seasonal presence of many prey species. Steller sea lions are generalist predators that eat a wide variety of prey, including many species of fish and cephalopods (including squid and octopus) (Pitcher and Calkins 1981; Calkins and Goodwin

1988; Calkins 1998; Sinclair et al. 2013; Tollit et al. 2017), and occasionally other marine mammals and birds (Pitcher and Fay 1982; NMFS 2008e).

During summer, Steller sea lions feed mostly over the continental shelf and shelf edge. During the breeding season, territorial adult males rarely or never eat while on breeding grounds (Loughlin and Gelatt 2017). Females attending pups forage within 37 km of breeding rookeries (Merrick and Loughlin 1997), and begin a regular routine of alternating foraging trips at sea, with nursing their pups on land a few days after birth. Lactating females spend more time at sea during winter than summer (Loughlin and Gelatt 2017).

Hearing

The ability to detect sound and communicate underwater is important for a variety of Steller sea lion life functions, including reproduction and predator avoidance. Studies of Steller sea lion auditory sensitivities have found that this species detects sounds underwater between 1 and 25 kHz (Kastelein et al. 2005), and in air between 250 Hz and 30 kHz (Mulsow and Reichmuth 2010). NMFS categorizes Steller sea lions in the otariid pinniped functional hearing group, with generalized hearing ranges of 60 Hz to 68 kHz in water and 90 Hz to 40 kHz in air (NMFS 2024b).

5 ENVIRONMENTAL BASELINE

The “environmental baseline” refers to the condition of the listed species, without the consequences to the listed species. 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 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).

5.1 Changing Environmental Conditions

All portions of the proposed project action area (Prudhoe Bay, the marine transit routes, and Cook Inlet) are being influenced by changing environmental conditions. 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 changing environmental conditions and increased atmospheric carbon dioxide (Doney et al. 2012), and these shifts have potentially far-reaching

biological effects. The impacts of changing environmental conditions are especially pronounced at high latitudes.

The Arctic continues to warm at a rate three times faster than the global mean¹⁷. 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 temperatures¹⁸. Some of the most pronounced effects of changing environmental conditions in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean temperatures and chemistry (Chapin et al. 2014).

One consequence of the warming is a reduction in the length of the snow season (Figure 55). The depth and duration of snow cover are projected to continue to decline substantially throughout the range of the Arctic ringed seal, reducing the areas with suitable snow depths for their lairs by an estimated 70 percent by the end of this century (Hezel et al. 2012). It has been observed that the mean thickness of snow accumulating on sea ice has declined from approximately 35 to 22 cm in the western Arctic and 33 to 15 cm in the Beaufort and Chukchi Seas since the mid-1900s (Webster et al. 2014). A decrease in the availability of suitable sea ice conditions (including depth of snow on ice available for lair formation) may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in seal populations (Loeng et al. 2005). The persistence of this species will likely be challenged as decreases in ice and, especially, snow cover lead to increased juvenile mortality from premature weaning, hypothermia, and predation (Kelly et al. 2010b). 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.”

¹⁷ NOAA. <https://arctic.noaa.gov/report-card/report-card-2024/2024-headlines/>, Accessed August 27, 2025.

¹⁸ NOAA. <http://www.arctic.noaa.gov/Report-Card/Report-Card-2017>, Accessed December 14, 2017.

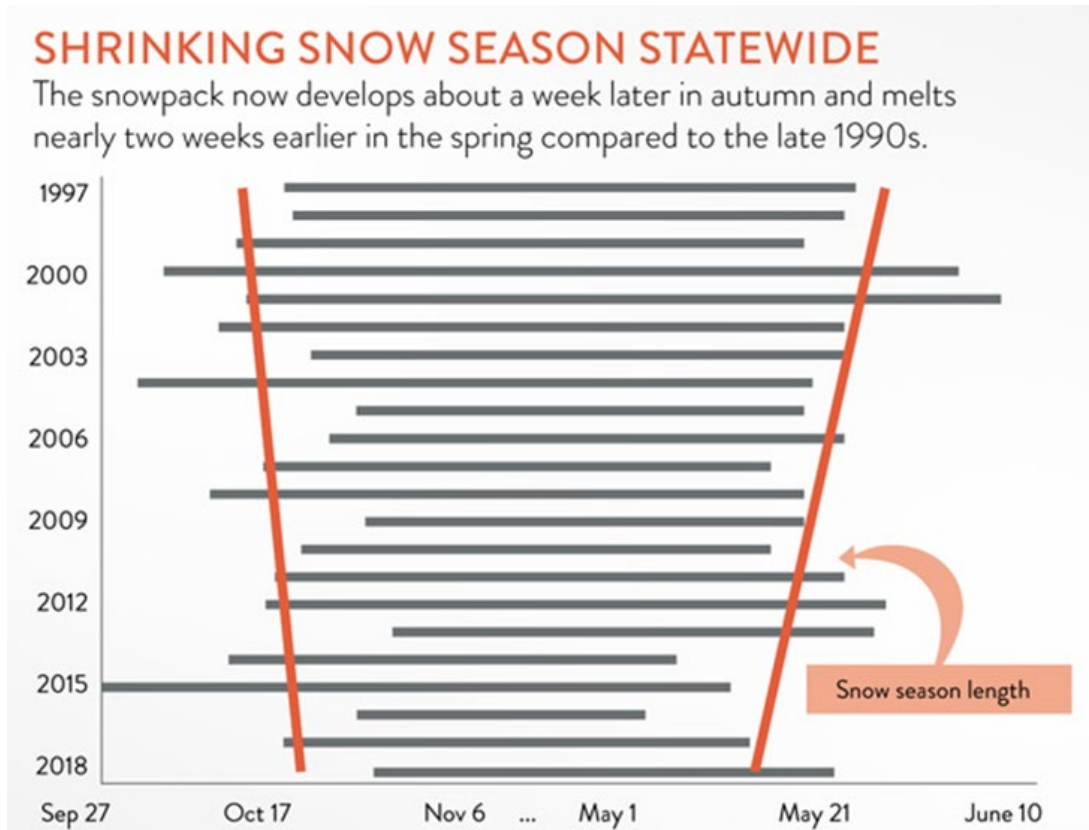


Figure 55. Length of the snow season (gray bars) in Alaska each year from 1997-2018. Orange slanting bars show the trends of the date when the state becomes 50 percent snow covered in fall and when half the winter snow has melted in spring. Image by Rick Thoman, Alaska Center for Climate and Policy.

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.

Because the sea ice extent and thickness have been decreasing consistently, vessel traffic, and more importantly for seals, ice breaker traffic will be increasing in the Arctic (U.S. Committee on the Marine Transportation System 2019; NMFS 2020c). Although seals are maneuverable enough to avoid vessels in open water, icebreakers could be lethal to nursing pups through collisions or crushing by displaced ice (Wilson et al. 2017; Wilson et al. 2020). In a study of Caspian seals (*Pusa capsica*) from 2006-2013, Wilson et al. (2017) documented the response of seals to ice breakers that made regular transits across the Caspian Sea. The ice breaking route had high densities of breeding seals in most years. A whole range of impacts to mothers and their pups was documented including being struck by the ice breaker, moving away from the ice breaker as it approached, and having mothers and pups separated. Vessel passage may destroy birth sites, water access holes, and pup shelters replacing those features with brash ice or open water. Often pups were marooned on fragments of intact ice or wetted in brash ice. Fragmented

brash ice may cause disorientation, stress, and increased energetic demands (Wilson et al. 2017). With the Northern Sea Route and Northwest Passage being available more often and an increase in icebreakers, we will expect that ice dependent seals could be affected.

With an earlier retreat of sea ice in the spring and warmer ocean temperatures, there have been changes in the distribution of whales. Aerial surveys to study the distribution, relative abundance, and behavior of marine mammals have been conducted in the eastern Chukchi Sea, primarily during July through October, 1982–1991 and 2008–2016, for the Aerial Surveys of Arctic Marine Mammals (ASAMM) project and its precursors (Brower et al. 2018). Although historical records from commercial whaling and scientific research document humpback, fin, and minke whales from June through October in the western Chukchi Sea and near the Chukotka coast, few records of these subarctic species exist in the eastern Chukchi Sea (Clarke et al. 2013a) and these species were entirely absent from this area in the 1982–1991 surveys (Brower et al. 2018). In contrast, there were 159 sightings of 250 individuals of these species in 2008–2016 in the eastern Chukchi Sea (Brower et al. 2018).

In addition to these observations, passive acoustic monitors (PAM) have been recording the presence of subarctic species in various parts of the Chukchi Sea (Delarue et al. 2013; Hannay et al. 2013; Crance et al. 2015; Tsujii et al. 2016; Stafford et al. 2022). These species generally arrive in the southern Chukchi Sea after the sea ice melts (late July) and leave before it extends over the area in October or early November (Hannay et al. 2013; Tsujii et al. 2016). PAM also recorded the farthest northeast record of fin whale calls in the Alaskan Arctic (Crance et al. 2015) and the extended use of the area by killer whales (Stafford et al. 2022). We would expect as sea ice continues to decline, presence of these subarctic species in more northerly latitudes will increase.

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 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 416 ppm and continues to rise (Figure 56).

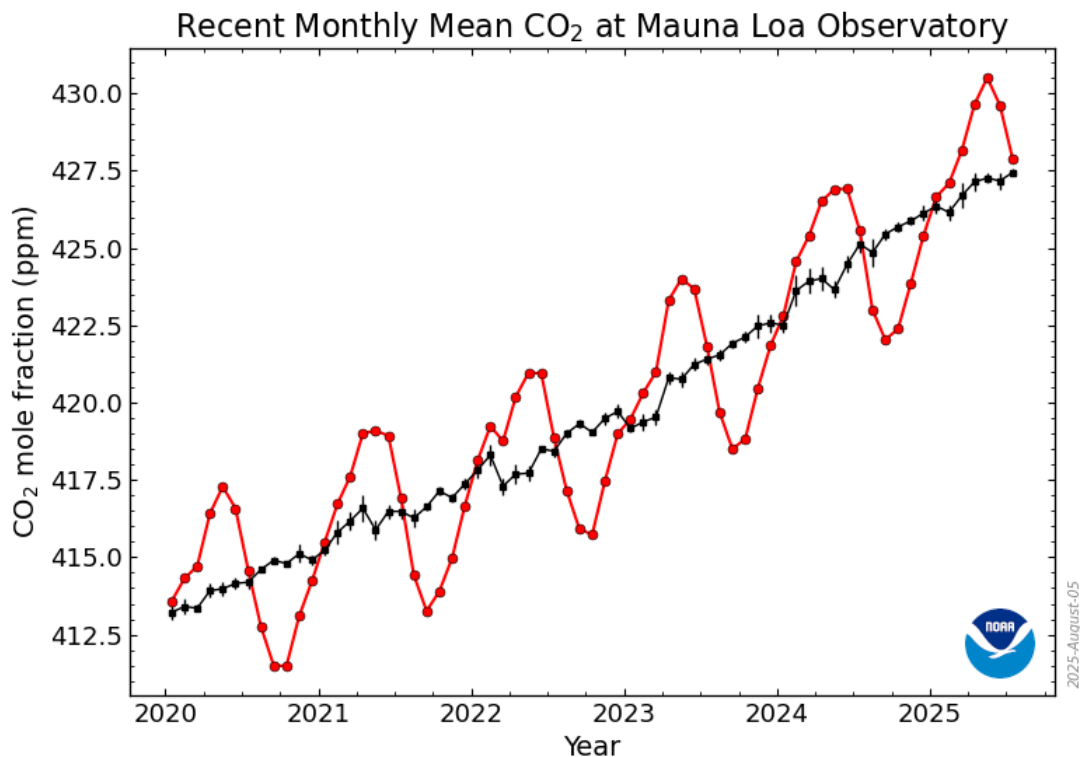


Figure 56. Monthly mean atmospheric carbon dioxide concentrations measured at Mauna Loa Observatory, Hawaii. (Data from NOAA Earth System Research Laboratory, Global Monitoring Division, available at <https://gml.noaa.gov/ccgg/trends/>, accessed August 27, 2025).

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).

As temperatures in the Arctic waters warm and sea ice diminishes, marine mammal health may be compromised through nutritional and physiological stress, and toxins from harmful algal blooms. *Alexandrium catenella*, a cyst-forming dinoflagellate creates a potent biotoxin, saxitoxin or paralytic shellfish poison. An exceptionally large cyst bed has been documented in the Chukchi Sea that can support germination and the development of recurrent, locally originating blooms (Anderson et al. 2021). Cyst concentrations are among the highest reported globally for this species and the cyst bed is at least six times larger in area than any other (Anderson et al. 2021). The region is now poised to support annual blooms that are massive in scale (Anderson et al. 2021). Fey et al. (2015) found that across all animal taxa, biotoxicity from harmful algal blooms was one of the events most often associated with mass mortality events. Domoic acid, another biotoxin produced by diatoms, was first recognized as a threat to marine mammal health in 1998 when hundreds of California sea lions (*Zalophus californianus*) died along beaches in central California or exhibited signs of neuroexcitotoxicity including seizures, head weaving, and ataxia (Scholin et al. 2000). Although biotoxins can cause death, they can also cause sublethal effects including reproductive failure and chronic neurological disease (Broadwater et al. 2018).

Lefebvre et al. (2016) examined 13 species of marine mammals from Alaska including the humpback whale (*Megaptera novaeangliae*), bowhead whale (*Balaena mysticetus*), beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), northern fur seal (*Callorhinus ursinus*), Steller sea lion, harbor seal (*Phoca vitulina*), ringed seal, bearded seal, spotted seal (*Phoca largha*), ribbon seal (*Histiophoca fasciata*), Pacific walrus (*Odobenus rosmarus divergens*), and northern sea otter (*Enhydra lutris*) for the presence of biotoxins (Figure 57). Domoic acid and saxitoxin (a form of paralytic shellfish poison) were both found in ringed seals (Lefebvre et al. 2016). It is not known if exposure to multiple toxins results in additive or synergistic effects or perhaps suppresses immunity to make animals more vulnerable to secondary stressors (Broadwater et al. 2018). With declining sea ice, warmer water temperatures, and changes in ocean circulation patterns, NOAA anticipates that harmful algal blooms in the Arctic will likely worsen in the future¹⁹.

Hendrix et al. (2021) examined 998 seals harvested for subsistence purposes in western and northern Alaska during 2005–2019 for domoic acid and saxitoxin. Both toxins were detected in bearded, ringed, and spotted seals, though no clinical signs of acute neurotoxicity were reported in harvested seals. Bearded seals had the highest prevalence of each toxin, followed by ringed seals. Bearded seal stomach content samples from the Bering Sea showed a significant increase in domoic acid prevalence with time (logistic regression, $p = .004$). These findings are consistent

¹⁹ NOAA Arctic Program. Arctic Report Card: Update for 2018, Available at <https://arctic.noaa.gov/report-card/report-card-2018/harmful-algal-blooms-in-the-arctic/>, accessed November 22, 2023.

with predicted northward expansion of domoic acid-producing algae. A comparison of paired samples taken from the stomachs and colons of 15 seals found that colon content consistently had higher concentrations of both toxins (Hendrix et al. 2021).



Figure 57. Algal toxins detected in 13 species of marine mammals from southeast Alaska to the Arctic from 2004 to 2013 (Lefebvre et al. 2016).

In addition to influencing animal nutrition and physiological stress, environmental shifts caused by changing environmental conditions may foster exposure to new pathogens in Arctic marine mammals. Through altered animal behavior and absence of physical barriers, loss of sea ice may create new pathways for animal movement and introduction of infectious diseases into the Arctic. The health impacts of this new normal in the Arctic are unknown, but new open water routes through the Arctic suggest that opportunities for Phocine distemper virus (PDV) and other pathogens to cross between North Atlantic and North Pacific marine mammal populations may become more common (VanWormer et al. 2019). PDV is a pathogen responsible for extensive mortality in European harbor seals (*Phoca vitulina vitulina*) in the North Atlantic. Prior to 2000, serologic surveys of Pacific harbor seals (*Phoca vitulina richardsii*), Steller sea lions, and northern sea otters off Alaska showed little evidence of exposure to distemper viruses, and PDV had not been identified as a cause of illness or death. PDV was not confirmed in the North Pacific Ocean until it was detected in northern sea otters sampled in 2004 (VanWormer et al. 2019). In addition to PDV, *Brucella*, and Phocid herpesvirus-1 have been found in Alaskan marine mammals (Zarnke et al. 2006). Herpesviruses were implicated in fatal and nonfatal infections of harbor seals in the North Pacific (Zarnke et al. 2006).

Ringed seals have co-evolved with numerous parasites and diseases, and these relationships are presumed to be stable. However, beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including

ringed seals, bearded seals, spotted seals, and walruses, in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012 through 2014 detected few new cases similar to those observed in 2011. To date, no specific cause for the disease and deaths has been identified.

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. 2010c). 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. 2010c) and bearded seals. Some of the anticipated biological consequences of the changing Arctic conditions are shown in Table 37.

However, not all Arctic species are likely to be adversely influenced by global changing environmental conditions. 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 37. Summary of possible direct and indirect effects for Arctic marine mammals (focus on seals) related to changing environmental conditions (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

Changing environmental conditions and effects on seasonal ice area are affecting the marine transit route through the Bering, Chukchi, and Beaufort seas.

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 environmental conditions. 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.

Cook Inlet beluga whales likely rely on the combined salmon escapement from multiple watersheds. Changes in prey availability to belugas may result from changes in the total availability, quality, species composition, and seasonality of prey. The greatest risks associated with changing environmental conditions may be potential changes in salmon and eulachon abundance. These changes could occur through regime shifts and changes in ocean ecosystems and/or through changes in these species' freshwater habitat. Temperature and hydrology control several critical stages in the life cycle of salmonids in their freshwater habitats. During periods of rapidly changing environmental conditions, these can have significant effects on anadromous salmonid populations (Bryant 2009).

Temperature is the most important abiotic factor influencing the physiology of fishes and the pathogenicity of their disease organisms (Brett 1971; Marcogliese 2001). Fish are particularly vulnerable to mortality during periods of increased water temperatures, and mortality may occur through several mechanisms, including increased virulence of pathogens, increases in metabolic rate that outstrip energy resources, and an oxygen demand that exceeds the heart's capacity to deliver oxygen (von Biela et al. 2020). Stream temperatures are closely related to air temperatures (Mohseni and Stefan 1999), and the annual surface air temperatures north of 60° N in 2023 were the sixth warmest dating back to 1900.²⁰

In June and July 2019, air temperatures over much of Alaska and the southern Yukon Territory reached record highs²¹ and salmon dying before they could spawn were recorded in the Yukon River (von Biela et al. 2020), the Koyukuk River (Westley 2020), the Igushik River (a tributary to Bristol Bay where it was estimated that a minimum of 100,000 salmon died),²² and the Kuskokwim River.²³ The parasites *Ichthyophonus* (a protozoan) and *Henneguya* (a cnidarian), which cause tapioca disease were prevalent in the salmon from the Kuskokwim. Pre-spawning mortality has also been documented in several Pacific Northwest watersheds, including the

²⁰ <https://arctic.noaa.gov/report-card/report-card-2023/surface-air-temperature-2023/> Accessed April 2024.

²¹ <https://www.ncei.noaa.gov/news/national-climate-201912> Accessed April 2024.

²² <https://alaskapublic.org/2020/01/15/in-some-bristol-bay-rivers-the-hottest-month-on-record-was-deadly-for-salmon/> Accessed April 2024.

²³ <https://www.kyuk.org/hunting-fishing/2019-07-12/record-warm-water-likely-gave-kuskokwim-salmon-heart-attacks> Accessed April 2024.

Fraser River in British Columbia (Hinch et al. 2012; Martins et al. 2012) and streams in the Lake Washington Basin in Washington (Barnett et al. 2020). The warming conditions during migration and spawning, in concert with other factors such as infections with pathogens, were responsible for the increased pre-spawning mortality of adult sockeye salmon, and were high enough to threaten the viability of the population (Barnett et al. 2020).

Mauger et al. (2017) monitored temperatures in 48 non-glacial streams across the Cook Inlet basin during open-water periods from 2008 to 2012 and found that numerous watersheds exceeded maximum weekly maximum temperature (MWMT) threshold ranges for the protection of salmon life stages. MWMT at most sites exceeded the established criterion for spawning and incubation during every year of the study, which suggests salmon are experiencing thermal stress in the Cook Inlet region (Mauger et al. 2017). The Deshka River, an important tributary to the Susitna River, had MWMT temperatures above 64°F during four years of the study period and above 68°F for three years (Mauger et al. 2017). As stream temperatures increase in response to increasing air temperatures, critical thresholds will likely be exceeded more often, especially when warm air temperature anomalies occur.

Population modeling linked Cook Inlet beluga reproductive success with salmon abundance in the Deshka River (Norman et al. 2020). Simulations showed that if salmon runs remained at their current levels, the Cook Inlet beluga whale population would likely continue the slow decline then observed and per capita births would continue to be low. However, Cook Inlet beluga whales forage at several streams throughout the summer and likely rely on the combined escapement from multiple watersheds. The concept of food resources limiting a cetacean population is not new, and reduced prey availability (Chinook salmon) has been directly linked to increased mortality and reduced health and survival of the Southern Resident killer whale population (Ward et al. 2009; Wasser et al. 2017).

In summary, the effects of changing environmental conditions will likely impact Cook Inlet beluga whales, primarily through their primary prey species, salmon. Warmer ocean temperatures, warmer stream temperatures, and warmer air temperatures will likely lead to many challenges and changes to the freshwater and marine ecosystems that salmon depend on. Pre-spawning salmon mortalities, reductions in returns, and shifts in run timing have already been documented.

Whether recent increases in the presence of humpback whales in Cook Inlet can be attributed to changing environmental conditions, 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 40). 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.

An unusual mortality event of large cetaceans occurred in Alaska waters in 2015-2016. Reports of dead whales included 22 humpback, 12 fin, two gray, one sperm, and six unidentified whales. There was an unusually large number of dead whales found in British Columbia during this time

as well. The strandings were concurrent with the arrival of the Pacific marine heatwave, one of the strongest El Niño weather patterns on record, decreasing ice extent in the Bering Sea, and one of the warmest years on record in Alaska in terms of air temperature.

Recent studies and observations have shown changes in distribution (Brower et al. 2018), body condition (Neilson and Gabriele 2020), and migratory patterns of humpback whales, likely in response to changing environmental conditions. The indirect effects of changing environmental conditions on humpback whales over time would likely include changes in the distribution of ocean temperatures suitable for many stages of their life history, the distribution and abundance of prey, and the distribution and abundance of competitors or predators.

The Pacific marine heatwave is also likely responsible for poor growth and survival of Pacific cod, an important prey species for Steller sea lions. The 2018 Pacific cod stock assessment estimated that the female spawning biomass of Pacific cod was at its lowest point in the 41-year time series considered. This assessment was conducted following three years of poor recruitment and increased natural mortality during the Gulf of Alaska marine heat wave from 2014 to 2016 (NMFS 2018b). The spawning stock biomass dropped below 20 percent of the unfished spawning biomass in 2020 and the federal Pacific cod fishery in the Gulf of Alaska was closed by regulation to directed Pacific cod fishing in 2020 as a result (Barbeaux et al. 2020). As of late 2023, Pacific cod abundance remained at reduced levels; however, the population is showing signs of growth.²⁴

The Steller Sea Lion Recovery Plan ranks environmental variability as a potentially high threat to recovery of the Western DPS (NMFS 2008d). The Bering Sea and Gulf of Alaska are subjected to large-scale forcing mechanisms that can lead to basin-wide shifts in the marine ecosystem resulting in significant changes to physical and biological characteristics, including sea surface temperature, salinity, and sea ice extent and amount.

Physical forcing affects food availability and can change the structure of trophic relationships by impacting climate conditions that influence reproduction, survival, distribution, and predator-prey relationships at all trophic levels. Warmer waters could favor productivity of some species of forage fish, but the impact on recruitment of important prey fish of Steller sea lions is unpredictable. Recruitment of large year-classes of gadids (e.g., pollock) and herring has occurred more often in warm than cool years, but the distribution and recruitment of other fish (e.g., osmerids) could be negatively affected (NMFS 2008d). Populations of Steller sea lions in the Gulf of Alaska and Bering Sea have experienced large fluctuations due to environmental and anthropogenic forcing (Mueter et al. 2009).

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

²⁴ <https://apps-afsc.fisheries.noaa.gov/REFM/docs/2023/GOABrief.pdf> accessed January 2024.

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 cortisols (Rolland et al. 2005), an immune system hormone. Extended periods of pituitary release of cortisols 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 2019d). 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 Appendix 3 of the Alaska Stock Assessment Reports (Young et al. 2024aPrudhoe 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.

The total estimated annual mortality and serious injury rate in U.S. commercial fisheries in 2012 through 2016 is 0.2 bowhead whales (Muto et al. 2019); however, the actual rate is currently unknown. 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.

5.2.1 Marine Transit Route

The North Pacific Fishery Management Council (NPFMC) adopted an Arctic Fishery Management Plan (FMP) that 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 currently occur in the Chukchi and Beaufort seas, any observed serious injury or mortality to listed species in the Arctic associated with commercial fisheries gear is currently attributable to interactions with fisheries in other areas, including in the BSAI management area.

In November 2022, AKR Sustainable Fisheries Division (SFD) indicated its intention to reinitiate consultation on the fishery management plans for the Gulf of Alaska (GOA) and Bering Sea and Aleutian Islands (BSAI) groundfish fisheries. The biological and conference opinion for the GOA FMP was completed December 23, 2024 (NMFS 2024c). AKR SFD prepared a BA analyzing the effects of the action on ESA-listed species and requested reinitiation of Section 7 consultation for BSAI FMP groundfish fisheries. A Biological Opinion for this action is currently under review.

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 2016f). 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. 2019).

Groundfish fisheries (including pollock, cod, flatfish, sablefish, rockfish, and other species) of the BSAI and GOA are managed by the NPFMC under separate but complementary FMPs. 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 Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea is allocated to fisheries in the Gulf of Alaska (including Southeast Alaska). The remainder is allocated and harvested in the BSAI. NMFS manages 10 crab stocks 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).

Although no commercial fisheries currently occur in the Chukchi and Beaufort seas some fisheries may be expected to expand or shift northward in response to an increased length of the ice-free, open-water season in the future. Indeed, signals of change came to Norton Sound in 2021, when a new commercial fishery was attempted by Icicle Seafoods. Two floating processors and fish tenders were anchored around Nome to process pink salmon (<https://www.arctictoday.com/in-alaskas-northern-bering-sea-a-commercial-pink-salmon-fishery-emerges/>, accessed March 2023). Development of this novel commercial fishery in Norton Sound also brought the introduction of purse-seining, in which nets are encircled around an area and then drawn closed. Purse seines can easily encircle marine mammals along with the target species as the net is set (<https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-purse-seines#risks-to-marine-mammals>, accessed March 2023), increasing the chance of bycatch.

5.2.1.1 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. 2011b); 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.

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 (Nemoto 1970; Kawamura 1980a; Hain et al. 1982b; Baker 1985; Geraci et al. 1989). 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.

5.2.2 Cook Inlet

Cook Inlet supports several commercial fisheries, all of which require permits. Commercial fisheries are divided into the upper and lower Cook Inlet regions.²⁵ The upper region contains 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).

²⁵ <http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareacookinlet.main> Accessed April 2024.

Sockeye salmon are the most economically valuable,²⁶ accounting for 92 percent of the total ex-vessel value over the past 20 years.²⁷

The average annual commercial harvest of salmon in upper Cook Inlet from 1966-2016 was 3.5 million (Shields and Dupuis 2017). The most recent 20-year average annual commercial salmon fishery harvest is 3.1 million fish, and the 2023 harvest of 1.9 million was 41 percent less than the 20-year average. The 2023 upper Cook Inlet commercial harvest compared to the recent 20-year average was down 2 percent for chum, 40 percent for sockeye, 53 percent for coho, 93 percent for Chinook, and 20 percent for pink salmon. Salmon are the primary prey item for Cook Inlet beluga whale and these numbers may be a cause for concern. At best, they indicate there are fewer salmon available for commercial fisheries, recreational, personal and subsistence use, and beluga whales.

The North Pacific Fishery Management Council first developed the Salmon Fishery Management Plan (FMP) under the Magnuson-Stevens Act more than 40 years ago. It excluded designated federal waters in Cook Inlet, which allowed the State of Alaska to manage commercial salmon fishing in the area. However, NMFS published a final rule implementing Amendment 16 to the Salmon FMP in April 2024, establishing Federal fishery management for all salmon fishing that occurs in the Cook Inlet EEZ, including commercial drift gillnet and recreational salmon fishery sectors (89 FR 34718, April 30, 2024). NMFS completed informal consultation in February 2024 concurring that the proposed Amendment 16 to the FMP was not likely to adversely affect the fin whale, Mexico DPS humpback whale, WNP DPS humpback whale, Western DPS Steller sea lion, or Cook Inlet beluga whale and its critical habitat.

Recreational fisheries exist in the river systems on the western Kenai Peninsula for salmon (Chinook, sockeye, pink, and coho), both freshwater and marine Dolly Varden char, and rainbow trout/steelhead trout. In the marine waters throughout Cook Inlet, recreational fishing occurs for salmon (Chinook and coho), Pacific cod, and halibut. Many of the charter fishing vessels targeting salmon and halibut operate out of Homer in lower Cook Inlet. A new recreational dipnet fishery on the Susitna River for all species other than Chinook salmon began in 2020.

Sport fishing for Chinook salmon in Cook Inlet salt waters was closed from May 15 through July 31, 2023,²⁸ and May 1 through August 15, 2024.²⁹ In conjunction with the 2023 closure, additional emergency orders prohibited the retention of wild Chinook salmon in the Ninilchik and Kasilof Rivers and restricted other Chinook salmon fisheries in the Susitna River, Northern Cook Inlet, and West Cook Inlet areas. Based on escapement monitoring in the Kenai, Anchor, and Deshka rivers, the Chinook salmon runs were forecast to be below the lower end of their escapement goals, which triggered the in-river sport fishery preseason closures in these streams.

²⁶ <http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareauci.main> Accessed April 2024.

²⁷ <https://www.adfg.alaska.gov/static/applications/dcfnewsrelease/1546815985.pdf> Accessed April 2024.

²⁸ <https://www.adfg.alaska.gov/sf/EONR/index.cfm?ADFG=region.NR&Year=2023&NRID=3455> Accessed April 2024.

²⁹ [https://www.adfg.alaska.gov/sf/EONR/index.cfm?ADFG=region.NR&Year=2024&NRID=3644#:~:text=\(Homer\)%20%2D%20In%20favor%20of,the%20latitude%20of%20Bluff%20Point](https://www.adfg.alaska.gov/sf/EONR/index.cfm?ADFG=region.NR&Year=2024&NRID=3644#:~:text=(Homer)%20%2D%20In%20favor%20of,the%20latitude%20of%20Bluff%20Point) Accessed April 2024.

Additionally, all of these stocks failed to achieve their escapement goals in 2022 and 2023. The low productivity period was expected to continue for Cook Inlet Chinook salmon in 2024.

Potential impacts from fishing on fin whales, humpback whales, Cook Inlet beluga whales, and Steller sea lions include ship strikes, harassment, gear entanglement, reduction of prey, and displacement from important habitat. For example, the Kenai River is the most heavily-fished river in Alaska;³⁰ belugas no longer use waters near the river during salmon fishing season, despite the fact that it has the largest salmon run in Cook Inlet and was heavily used beluga foraging habitat in the past (Ovitz 2019; Kumar et al. 2024).

5.2.2.1 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 (Murray and Fay 1979; Burns and Seaman 1986). 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 2016d).

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).

Humpback whales have been killed and injured during interactions with commercial fishing gear; however, the frequency of these interactions does not appear to have a significant adverse consequence for humpback whale populations. In Alaska, most humpbacks become entangled with gear between early June and early September while foraging in nearshore waters. A photographic study of humpback whales in Southeast Alaska found at least 53 percent of individuals showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005).

Human-caused mortality and injury reported for humpback whales in Alaska from 2016 to 2020 was 65 animals, 47 of which were entanglements (Freed et al. 2022). In 2015, a humpback whale was entangled in a salmon purse seine net in Cook Inlet but was cut free by the fisherman, and was assumed to be unharmed (Delean et al. 2020). A minke whale or small humpback whale was reported entangled near the Lands End hotel in Homer in 2017, and a humpback whale was

³⁰ <http://www.adfg.alaska.gov/index.cfm?adfg=ByAreaSouthcentralUpperKenai.fishingInfo> Accessed May 2023.

reported entangled near the Homer Spit in 2019 (NMFS unpublished data). These are the only known humpback whale entanglements in Cook Inlet.

Alaska Department of Fish and Game (ADFG) analyzed data from 1,439 individually marked Steller sea lions that were re-sighted from 2001 through 2015, and found that animals that had ingested salmon hook and line fishing gear had lower survival than comparable animals that had not ingested fishing gear (Freed et al. 2022). The minimum estimated mean annual mortality and serious injury rate in U.S. commercial fisheries between 2014 and 2018 was 37 Western DPS Steller sea lions, and this is likely an underestimate of the actual level (Muto et al. 2021). Between 2016 and 2020, human-caused mortality and injury of the Western DPS Steller sea lions ($n = 148$) was primarily caused by entanglement in fishing gear, in particular, commercial trawl gear ($n=113$; Freed et al. 2022). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries, and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. Overall, the relative impact on the recovery of the Western DPS of Steller sea lion due to entanglement is ranked as low (NMFS 2008d).

5.2.2.2 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; however, there are numerous reports of whales in the river before and after the summer salmon fishing season (Shelden et al. 2015b; Castellote et al. 2016; Kumar et al. 2024). Small watercraft have been observed harassing belugas out of the 20-mile River in Turnagain Arm, and within the Kenai River.

Cook Inlet belugas are dependent on access to relatively dense concentrations of high value prey species, particularly in the spring and throughout the summer months. John et al. (2024) estimated that an average adult beluga would need to consume four to five Chinook salmon, 12 coho salmon, 13 to 14 chum or sockeye salmon, or 28 pink salmon per day to meet their daily energy expenditure. During the summer, 350 Cook Inlet beluga whales were estimated to consume a total biomass of approximately 1,250 metric tons of fish (Norman 2011). Chum, coho, and other salmonid species constitute greater than 54 percent of their summer diet (Hobbs and Shelden 2008). The 2023 upper Cook Inlet commercial salmon fishery harvest was 1.9 million fish, 41 percent less than the most recent 20-year average. A reduction in the amount of available prey could impact Cook Inlet beluga whale energetics and delay recovery.

There has been debate among the scientific community as to whether fisheries reduce Steller sea lion prey biomass and quality at local and/or regional spatial scales, which then leads to a reduction in Steller sea lion survival and reproduction (NMFS 2008d). The most recent minimum

total annual direct mortality of Western DPS Steller sea lions associated with commercial fisheries is 37 individuals (Muto et al. 2021).

While fin and humpback whales may be present in lower Cook Inlet year-round, their major foraging areas are located outside of Cook Inlet and prey competition is unlikely to occur.

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 2016b). 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. Offshore oil and gas development in Alaska poses a number of threats to listed marine species, including increased ocean sound, risk of hydrocarbon spills, production of waste liquids, habitat alteration, increased vessel traffic, and risk of ship strike. NMFS reviewed the potential effects of oil and gas development in a Final Environmental Impact Statement for the effects of oil and gas activities in the Arctic Ocean (NMFS 2013b) and has conducted numerous Section 7 consultations on oil and gas activities in the Chukchi and Beaufort seas (available at <https://www.fisheries.noaa.gov/alaska/consultations/section-7-biological-opinions-issued-alaska-region>).

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.

Point Thomson, a gas condensate field, produces condensate that is shipped via a 22-mile oil pipeline to a tie-in into the Badami Oil Pipeline that then transports the oil to Pump Station 1 on the Trans-Alaska Pipeline. The drill site and production facilities are on State onshore lands just west of the Arctic Refuge. The project includes production pads, process facilities, an infield road system, a pipeline, infield gathering lines, and an airstrip.

Colville Delta 5 pad includes satellite field oil accumulations that transfers oil to the Alpine processing unit on state lands. The Colville Delta 5 pad is on Native-owned private lands within the NPR-A boundary. The participating areas produced from the Colville Delta 5 pad are primarily state and Native with some minor federal oil production. Colville Delta 5 began production in 2017 and is producing approximately 37,000 barrels of oil equivalent per day (BOEPD) from within the encompassing Colville River Unit (BLM 2020).

The Greater Mooses Tooth Unit (GMTU), formed in 2008, includes the Lookout and Rendezvous participating areas and is the first unit entirely within the National Petroleum Reserve Alaska (NPR-A). Construction began in 2017 with two phases: GMT1 and GMT2. GMT1 began production of the Lookout pool in 2018 and GMT2 achieved first oil from the Rendezvous pool in 2021. Both are connected to the Alpine processing facilities by gravel roads and pipelines. Combined production from GMT1 and GMT2 is approximately 14000 BOEPD. (ConocoPhillips 2023).

The Willow Project is a development (under construction) in the Bear Tooth Unit. The project is constructing three drill sites, with each designed and sized to accommodate all drilling and operations facilities, wellhead shelters, drill rig movement, and material storage. Each drill site is sized to accommodate 40 to 70 wells, and up to 200 total wells across the three pads. Willow will have its own processing facility. First oil production is scheduled for 2029. When operational, it is estimated that Willow production would have a peak of approximately 180,000 BOEPD.

Umiat is a historical oil and gas field that was first explored in 1944 by the U.S. Navy. The U.S. Navy drilled 12 exploration and delineation wells during 1944–1979, and lease holders drilled 2 additional wells in 2013 and 2014. Shallow oil was discovered in the Grandstand formation. Information from wells suggests that a larger pool exists below the shallow reservoir with an

estimated one billion barrels of oil in place (Oil and Gas Journal 2010, as cited in BLM 2025). In September 2019, the BLM received an application for an exploratory unit at Umiat that encompasses two federal leases.

In 2021, 88 Energy Ltd. discovered oil in the Cretaceous aged Nanushuk formation while drilling the Merlin 1 well, located north of Umiat. The extent of the reservoir is not confirmed until additional delineation wells can be drilled (Bradner 2021, as cited in BLM 2025).

The Horseshoe Unit was established in 2022 and is located partially within the NPR-A and State managed lands east of the Colville River. The unit is operated by Repsol and Santos. In 2015, Armstrong Energy and Repsol discovered the Pikka oil field, followed by the Horseshoe discovery in 2017, both within the Nanushuk Formation. The U.S. Geological Survey assessed the combined field at 1.2 BBO of technically recoverable oil (Houseknecht et al. 2017).

The Pikka project (formerly known as the Nanushuk Development Project) is southeast of the East Channel of the Colville River, approximately 52 miles west of Deadhorse and about 6.5 miles from Nuiqsut (at the southernmost project boundary). The project will include construction of the Nanushuk pad, comprised of drill site 1, a central processing facility (CPF), drill site 2, drill Site 3, an operations center pad, infield pipelines, the export/import Nanushuk pipeline, infield roads, an access road, a tie-in pad, and a potable water system. The project also includes temporary discharges to 5.8 acres of jurisdictional waters of the United States for screeding at the Oliktok Dock.

Efforts to develop the Narwhal Reservoir may occur in the future. The target area is located primarily in the Colville River Unit. Production from this reservoir could occur from existing pads, such as the CD1 or CD4 pads, from a drill site at or near the location of the 2018 Putu exploration well, or a combination of these. If development occurs from an existing pad, there may be accompanying pad expansion. If a new drill site is constructed, ConocoPhillips Alaska expects that it would connect by road and pipeline to existing Alpine infrastructure. ConocoPhillips Alaska anticipates that any fluids produced from an existing or new drill site would be processed at the Alpine CPF.

Many of the consultations have analyzed the take (by harassment) of listed species from sounds produced during geophysical (including seismic) surveys and drilling operations conducted by leaseholders during open water (i.e., summer) months. Geophysical seismic survey activity has been described as one of the loudest man-made underwater sound sources, with the potential to harass or harm marine mammals (Richardson et al. 1995b). Controlled-source, deep-penetration reflection seismology, similar to sonar and echolocation, is the primary tool used for onshore and offshore oil exploration (Smith et al. 2017). Seismic surveys are conducted by towing long arrays of sensors affixed to wires at approximately 10 knots behind large vessels following a survey grid. High power air cannons are fired below the water surface, and the sound waves propagate through the water and miles into the seafloor. When those soundwaves encounter strong impedance contrasts (e.g., between water and the ocean floor, or between different densities of substrates), a reflection signal is detected by the sensors. Those signals can be interpreted to determine the stratigraphy of the substrate and identify oil and gas deposits.

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 Richardson 1988; Greene and Moore 1995). 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, it strongly supports sound propagation in the 50 to 500 Hz frequency band (Funk et al. 2008). The sound generated from seismic surveys has been linked to behavioral disturbance of wildlife and potential auditory injury to marine mammals in the marine environment (Smith et al. 2017). Seismic surveys are often accompanied 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.

5.3.1.1 Pollution and Discharges (Excluding Spills)

Previous development and discharges 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 marine mammals or their prey (NMFS 2013b). Drill cuttings and fluids contain contaminants that have high potential for bioaccumulation, such as dibenzofuran and polycyclic aromatic hydrocarbons. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea near the action area, and residues from historical discharges may be present in the affected environment (Brown et al. 2010b). Polycyclic aromatic hydrocarbons are also emitted to the atmosphere by flaring waste 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 EPA to administer the 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, Subpt. M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued. The EPA has issued an NPDES permit (permit #AK0053783) for the Navy Arctic Ice Camp effective January 1, 2022, through December 31, 2026, for the discharge of pollutants (camp graywater and reverse osmosis reject water) from specified outfalls located within the area of camp operations.³¹

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 outer continental shelf (OCS) is also in the CWA. Discharges are covered under the Vessel Incidental

³¹ <https://www.epa.gov/npdes-permits/npdes-permit-us-navy-arctic-ice-camp-alaska>, accessed 1/3/2024

Discharge Act, which is in the CWA Section 312(p) (33 USC 1322(p))³². 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.

5.3.1.2 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). Offshore petroleum exploration activities have been conducted in State of Alaska waters in 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, 43 wells have been drilled in the Beaufort and Chukchi seas 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. On average, approximately 2,000 oil and hazardous substance spills are reported to the Alaska Department of Environmental Conservation (DEC) every year.³³ Most were in nearshore and shallow coastal waters and were primarily diesel (BLM 2019). Only one percent of the spills were crude oil. If a marine mammal came in direct contact with a small, refined oil spill it could experience inhalation and respiratory distress from hydrocarbon vapors, or ingestion directly or indirectly by consuming contaminated prey, and less likely skin and conjunctive tissue irritation (Engelhardt 1987). Certain marine mammals may also be prone to fouling of pelage by oil, which may subsequently be ingested during grooming or cleaning. Small offshore spills of refined petroleum products are expected to dissipate rapidly. A small spill could impact marine mammals through their ingestion of contaminated prey, but prey contamination likely will be localized and temporary.

Marine mammals can ingest spilled compounds while feeding, inhale the volatile components, or be affected by direct contact. Effects of oil ingestion on marine mammals can range from progressive organ damage to death, depending on the quantity and composition of the ingested oil (Geraci and St. Aubin 1990). The effects of an oil spill on marine mammals would depend largely on the size, season, and location of the spill. Surface contact with oil spills can damage mucous membranes and eyes of seals, or disrupt thermoregulation in seal pups (Geraci and St. Aubin 1990). If a spill were to occur during the ice free, open water season, seals may be exposed to oil through direct contact, or perhaps through contaminated food items. However, St. Aubin (1990) notes that with their keen olfaction and good vision, seals may be able to detect and avoid oil spills in the open water season (St. Aubin 1990).

³² <https://www.epa.gov/vessels-marinas-and-ports/vessel-incident-discharge-act-vida>

³³ <https://dec.alaska.gov/spar/ppr/response-resources/local-response>, viewed 12/19/2023

Immersion studies by Geraci and Smith (1976) found ringed seals may develop mild liver injury, kidney lesions, and eye injury from immersion in crude oil. The eye damage was often severe, suggesting permanent eye damage might occur with longer periods of exposure to crude oil, and the overall severity of the injuries was most likely associated with the exposure duration to crude oil. Geraci and Smith (1976) concluded the direct effects of an oil blow-out or spill may result in transient eye damage to healthy seals in open water; however, ringed seals exposed to a slick of crude oil showed no impairment in locomotion or breathing.

If marine mammals have encountered any of the spills that have occurred in their habitat, these encounters have not been documented. The small size of the spills and the dispersive action of waves and currents likely has reduced the probability of an encounter and adverse reaction to extremely low levels. While the potential for a large spill exists, and could have devastating effects on marine mammals we have no evidence that the spills that have occurred are negatively affecting marine mammals at this time. 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 38 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 38. Oil spill assumptions for the Beaufort and Chukchi Seas Planning Areas, 2012-2017

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 (Simmonds and Elliott 2009; Hossain et al. 2014; Laidre et al. 2015). More information about spills in this region can be found in the *Pollutants and Contaminants* section (Section 5.6).

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), and there were attempts at oil exploration along the west side of Cook Inlet prior to that. Fourteen offshore oil production facilities were installed in upper Cook Inlet by the late 1960s, and today there are 17 offshore oil and gas platforms. Figure 58 shows the ongoing oil and gas activities in state waters as of December 2023. There are 200 active oil and gas leases in Cook Inlet that encompass approximately 394,403 acres of State leased land, of which 322,801 acres are offshore (Figure 59).

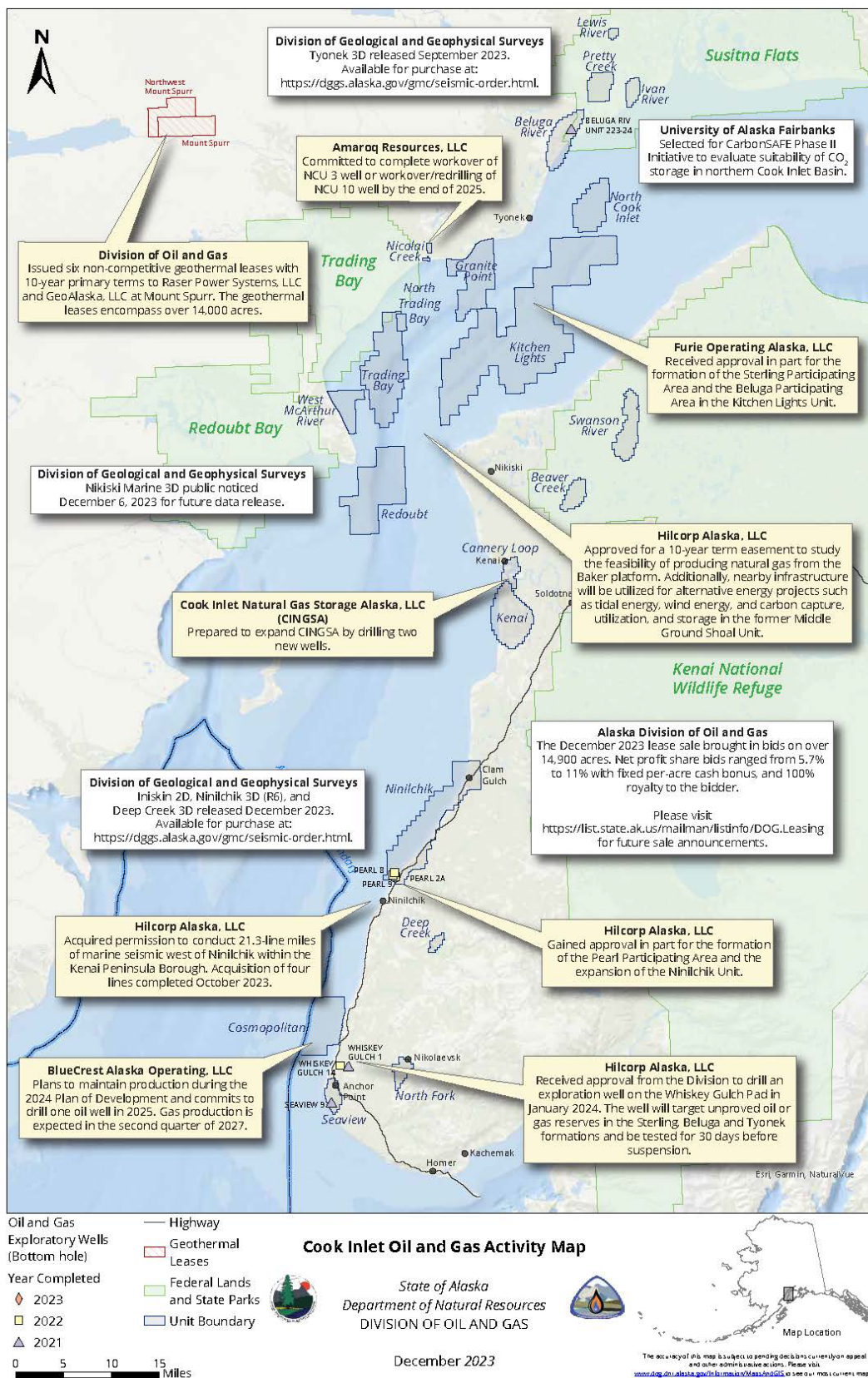


Figure 58. Oil and gas activity in Cook Inlet as of December 2023

Approximately 3.3 million acres were up for bid in the state-owned lease sale in June 2021, and HEX Group and Strong Energy Resources successfully bid on nearly 21,000 acres of oil and gas tracts in Cook Inlet. Hilcorp successfully bid on nearly 23,000 acres of oil and gas tracts in the 2022 state-owned lease sale. In the 2023 state-owned lease sale, HEX, LLC successfully bid on 1,674 acres and Hilcorp successfully bid on 13,324 acres.

BOEM held Lease Sale 244 in Cook Inlet in 2017 (NMFS 2017b). Hilcorp was the only responding company and their successful bids on 14 tracts/blocks encompassed 31,005 acres. NMFS issued Incidental Take Regulations for Hilcorp's oil and gas activities (NMFS 2019c); the seismic surveys and other activities are discussed below. Lease Sale 258 in Cook Inlet was cancelled in May 2022 due to lack of industry interest; however, BOEM was directed by the Inflation Reduction Act of 2022 to hold Lease Sale 258 by the end of 2022 Figure 60. One bid on one block was received and awarded to Hilcorp in March 2023. A court order suspended the lease in July 2024.

5.3.2.1 Kenai LNG Plant

The Kenai liquefied natural gas (LNG) liquefaction and terminal complex began operating in 1969 and, until 2012, was the only facility in the United States authorized to export LNG produced from domestic natural gas. LNG shipments from the terminal began declining and the plant has been in a warm-idle state since 2015. In early 2019, NMFS was informed that there were plans to bring the plant back into operation in the next few years. The Federal Energy Regulatory Commission (FERC) approved the Trans-Foreland Pipeline Company's request to convert the facility to an importing plant in December 2020 and gave the company until December 2022 to place it into service. The Trans-Foreland Company requested an extension to complete the facility by December 2025, which FERC approved in August 2022.³⁴

Oil and gas development will likely continue in Cook Inlet; however, the overall effects on listed marine mammals are unknown (NMFS 2008a; NMFS 2008d). 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 2016c).

³⁴ <https://www.reuters.com/business/energy/marathon-gets-more-time-build-lng-import-project-alaska-2022-08-16>
Accessed March 2024.

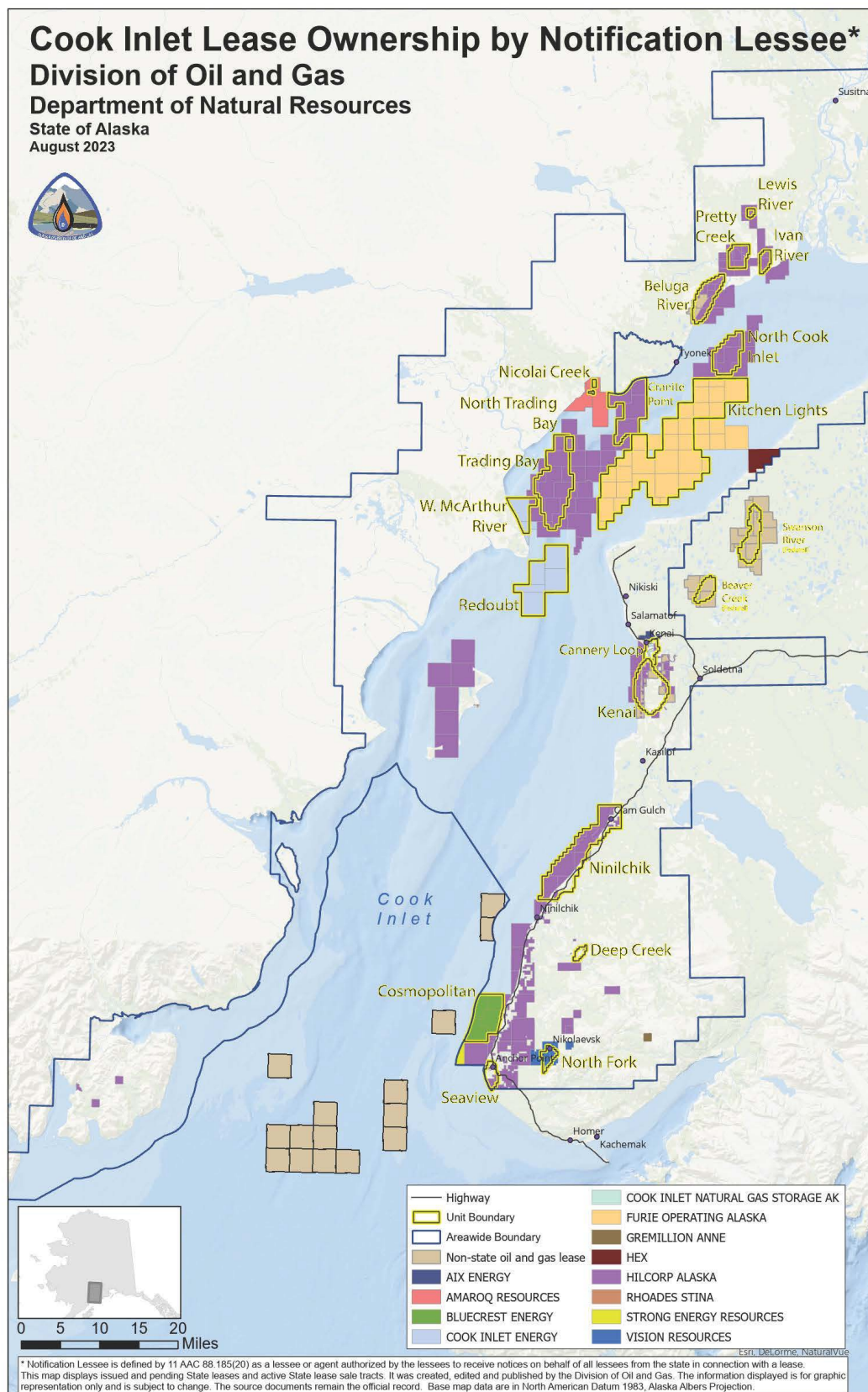


Figure 59. Cook Inlet lease ownership by notification lessee

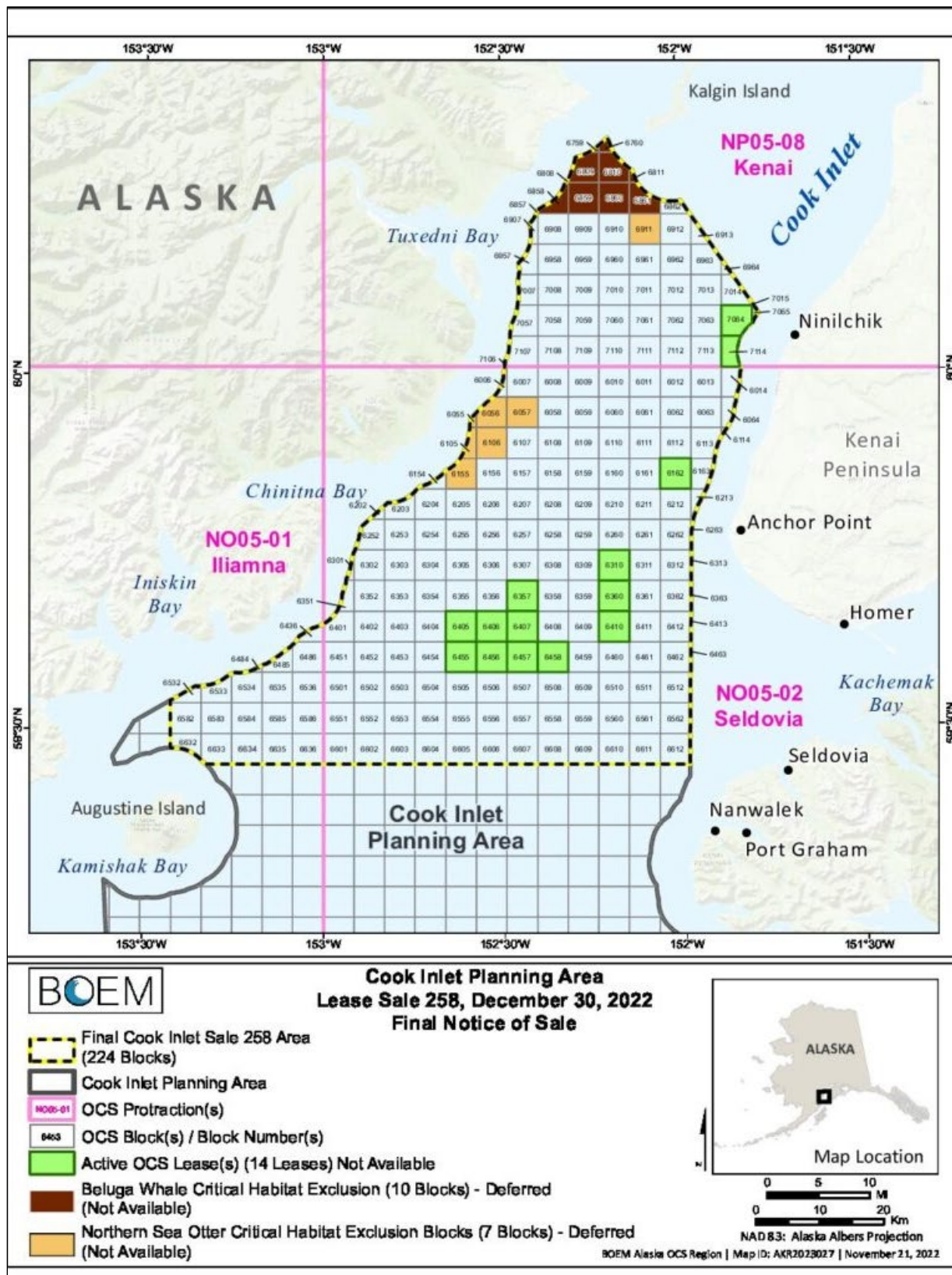


Figure 60. Lease Sale 258 final notice of sale

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 61). 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.

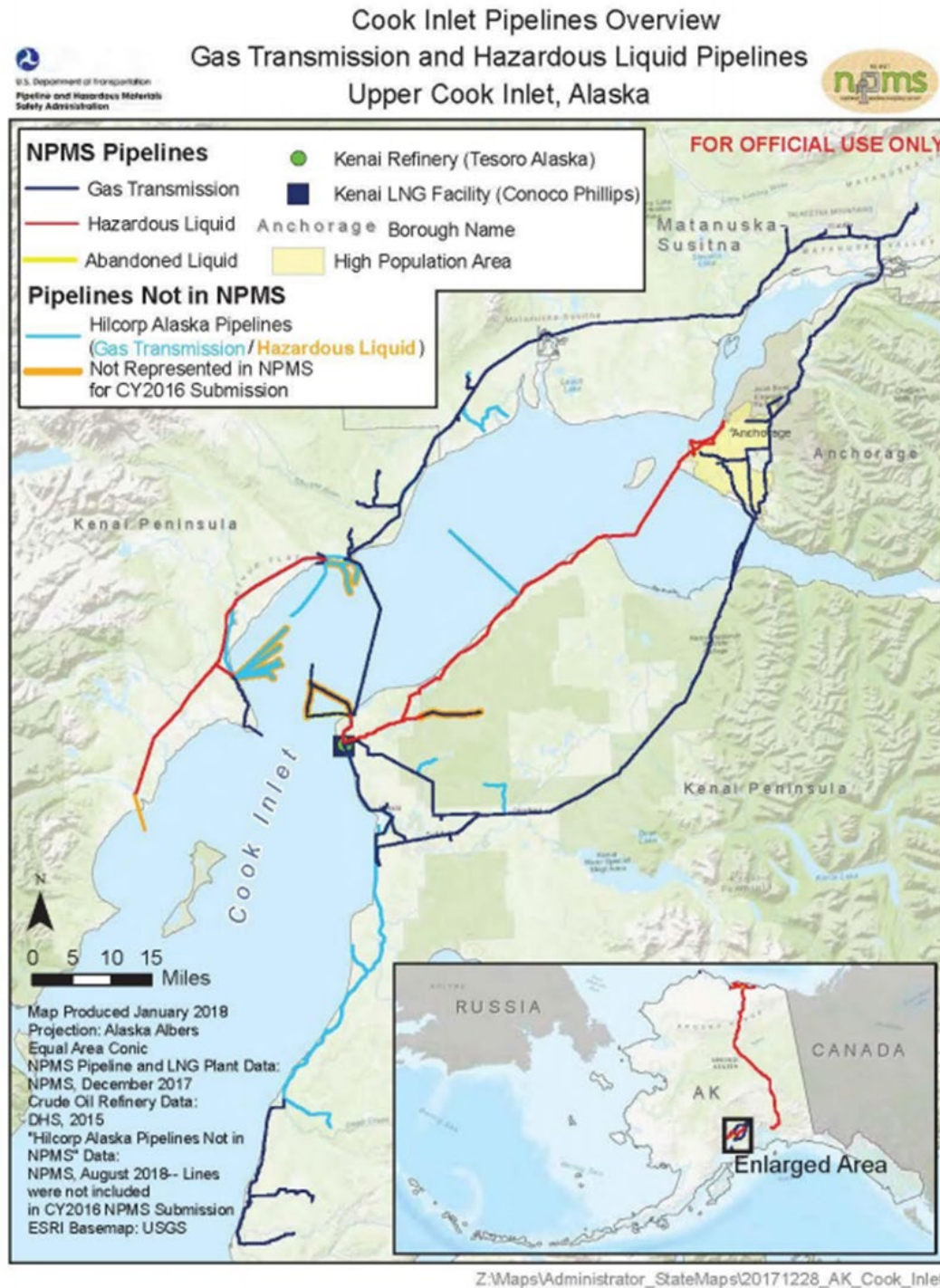


Figure 61. Existing pipelines in Cook Inlet

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 2018f). This project was completed in 2018 (Sitkiewicz et al. 2018b). The IHA authorized Level B harassment of 40 Cook Inlet beluga whales, 6 Steller sea lions, and 5 humpback whales (NMFS 2018e). PSOs observed 814 beluga whales, 3 humpback whales, and 2 Steller sea lions during project activities. Of the 819 listed animals observed, only 1 humpback whale was considered exposed to sound exceeding the Level B harassment threshold (Sitkiewicz et al. 2018a).

5.3.2.5 Tidal Energy

Ocean Renewable Power Company (ORPC), a developer of renewable power systems that harness energy from free-flowing rivers and tidal currents, submitted a preliminary permit application to FERC in May 2021 for a project in Cook Inlet. ORPC previously conducted site characterization and environmental studies in the region, and intends to develop a five-megawatt pilot project near East Foreland to verify the technical performance and environmental compatibility of its proposed project. Project results will assist in planning a phased build-out of up to a 100-megawatt commercial-scale project.³⁵ ORPC will collaborate with Homer Electric Association, Inc. to sell the tidal energy produced. Work on this project has not begun, nor have proposed construction dates been conveyed to NMFS.

ORPC is also partnering with the Matanuska-Susitna Borough to test its RivGen Power System at Port MacKenzie.³⁶ They plan to evaluate the ability to harness the tidal current of upper Knik Arm to power the cathodic protection systems, which prevent the metal structures from corroding, at the port.

³⁵ https://www.renewableenergymagazine.com/ocean_energy/orpc-plans-to-advance-tidal-energy-in-20210526 Accessed April 2024.

³⁶ <https://www.akbizmag.com/industry/energy/testing-tidal-power-in-knik-arm/> Accessed April 2024.

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 decreases in sea ice in the Bering, Chukchi, and Beaufort seas (Neilson et al. 2012) driven by changing environmental conditions. 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. Decreasing Arctic Sea ice will: (1) facilitate an increase in vessel traffic associated with oil and gas exploration; (2) allow for increased tourism; and (3) open historically closed trade routes. Vessel traffic in the Chukchi and Beaufort seas is currently limited to late spring, summer, and early autumn. However, 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 expected over the coming decades, likely resulting in increased vessel traffic and increased duration of the navigation season. 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 (Adams and Silber 2017).

Shipping in the Arctic is expected to increase as sea ice decreases. Both major shipping routes, the Northern Sea Route along the northern Russian coast and the Northwest Passage through the Canadian Archipelago, pass through Bering Strait. The entire population of bowhead whales passes through the Bering Strait each spring and fall between wintering and summering areas (Quakenbush et al. 2012). There are about 33 km (20 mi) between the west side of the Diomedes Islands and the Chukotka coast. Ships traveling along the coast between October and December could encounter a high proportion of the bowhead population (Quakenbush et al. 2012). Ship strikes are the greatest source of mortality for North Atlantic right whales (*Eubalaena glacialis*) and bowhead and North Pacific right whales may be as vulnerable to ship strikes as North Atlantic right whales due to their swimming speed and feeding behavior (Reeves et al. 2012).

Two percent of subsistence-harvested bowheads bear scars from vessel encounters (George et al. 2017a). In addition, with the expansion of habitat by the subarctic species to the north, interactions with ship traffic in the Bering Strait is an area of concern for all species (Reeves et al. 2012).

The U.S. Committee on the Marine Transportation System (CMTS) reported that the number of vessels operating in the Chukchi and Beaufort seas increased 128 percent from 2008 to 2018. The vessels include those used for research, natural resource exploration and extraction, commercial shipping, government/law enforcement/search and rescue, and tourism. Of the 255 vessels that transited through the US Arctic and surrounding region from 2015-2017, over 50 percent were tug, towing, and cargo vessels. Thirty-two flag states transited the region, although US flagged vessels were the most prevalent. The length of the navigation season has been growing by as much as 7-10 days annually, which, extrapolated over the next decade, could result in a 2.5 months longer navigation season over what was seen in 2019 (U.S. Committee on the Marine Transportation System 2019).

In the projections developed by the CMTS for the most plausible scenario, 72 vessels are expected to be active annually by 2030 in natural resource exploration and development, which is also the activity ranked as the largest contributor to projected traffic growth. More than 50 percent of this growth is expected to be from non-US natural resource extraction (Russian exports of LNG and mineral extraction in Canada). By 2030 in the most plausible scenario, 28 vessels are expected to be active for rerouted shipping through the Arctic and 17 vessels in the expansion of the Arctic fleet (icebreakers, and ice-hardened cruise ships). However, these estimates do not include the small vessel transits used for commercial fishing, subsistence harvest, or lightening goods from large barges to shore using smaller vessels.

Marine vessel traffic may pose a threat to bowheads, bearded seals, and ringed seals in the action area, because of ship strikes and vessel sound. The U.S. Committee on the Marine Transportation System (CMTS) reported that about 255 vessels transited through the US Arctic and surrounding region from 2015-2017, as determined by automatic identification system (AIS) data.

More details on vessel traffic in the Prudhoe Bay area can be found in Section 4.1.1.1.

5.4.1.1 Vessel Noise

Vessel sound can create auditory interference, or masking, in which the sound can interfere with an animal's ability to understand, recognize, or even detect sounds of interest. This can lead to behavioral changes in marine mammals, such as increasing their communication sound levels or causing them to avoid noisy areas. Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the oceans (Simmonds and Hutchinson 1996; NRC 2003b). 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 sound associated with vessel operations is the continuous sound produced from propellers and other on-board equipment. Cavitation sound is expected to dominate vessel acoustic output when tugs are pushing or towing barges or other vessels. Other sound 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 2011b) 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 away from a receiver generally contribute only to background-sound levels (Greene and Moore 1995). Sound 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 (Greene and Moore 1995; Austin et al. 2015); 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. In a study of Caspian seals (*Pusa capsica*) from 2006-2013, Wilson et al. (2017) documented the response of seals to ice breakers that made regular transits across the Caspian Sea. The ice breaking route had high densities of breeding seals in most years. A whole range of impacts to mothers and their pups was documented including being struck by the ice breaker, moving away from the ice breaker as it approached, and having mothers and pups separated. Vessel passage may destroy birth sites, water access holes, and pup shelters replacing those features with brash ice or open water. Often pups were marooned on fragments of intact ice or wetted in brash ice. Fragmented brash ice may cause disorientation, stress, and increased energetic demands (Wilson et al. 2017). With the Northern Sea Route and Northwest Passage being available more often and an increase in icebreakers, we will expect that ice dependent seals could be affected.

5.4.1.2 Vessel Strikes

Current shipping activities in the Arctic pose varying levels of threats to marine mammals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with their habitats. 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 (Smiley and Milne 1979; Mansfield 1983). In 2021, a bearded seal carcass had definite signs of vessel strike; however, it is unknown if the vessel strike occurred pre or postmortem.³⁷ To date, there are no known vessel strikes of ringed seals. However, Sternfeld (2004a) documented a single spotted seal stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike.

Vessel strikes of whales occur throughout Alaska, but are less common in the action area than in the Gulf of Alaska and Southeast Alaska. Free-ranging marine mammals often engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators. There has been one reported vessel strike of a bowhead whale from Utqiagvik in 2015 (NMFS unpublished data); evidence from subsistence-harvested bowhead whales indicate about two percent of animals have experienced vessel

³⁷ AKR Regional Stranding Number 2021239

collisions (George et al. 2017). Increased vessel traffic resulting from a reduction in sea ice in the Arctic may lead to more vessel strike incidents in the future.

5.4.2 Marine Transit Route

The entire population of bowhead whales passes through the Bering Strait each spring and fall between wintering and summering areas (Quakenbush et al. 2012). There are about 33 km between the west side of the Diomedes Islands and the Chukotka coast. Ships traveling along the coast between October and December could encounter a high proportion of the bowhead population (Quakenbush et al. 2012). Ship strikes are the greatest source of mortality for North Atlantic right whales (*Eubalaena glacialis*), and bowhead and may be as vulnerable to ship strikes as North Atlantic right whales due to their swimming speed and feeding behavior (Reeves et al. 2012). Two percent of subsistence-harvested bowheads bear scars from vessel encounters (George et al. 2017a). One carcass observed in 2019 during the ASAMM surveys had blubber sections with straight wound edges and was likely struck by a vessel (Willoughby et al. 2020). From 2021 to 2023, the annual percentage of harvested bowhead whales examined with likely vessel strike scarring ranged from 3 percent in 2022 to 8.7 percent in 2023 (Stimmelmayer et al. 2024). To date, no ringed seal carcasses have been found with propeller marks. However, Sternfeld (2004b) documented a single spotted seal stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike. Additionally, in 2021, a bearded seal carcass showed definite signs of vessel strike; however, it is unknown if the vessel strike occurred pre- or post-mortem.³⁸

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 62). 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 2015).

³⁸ AKR Stranding Number 2021239.

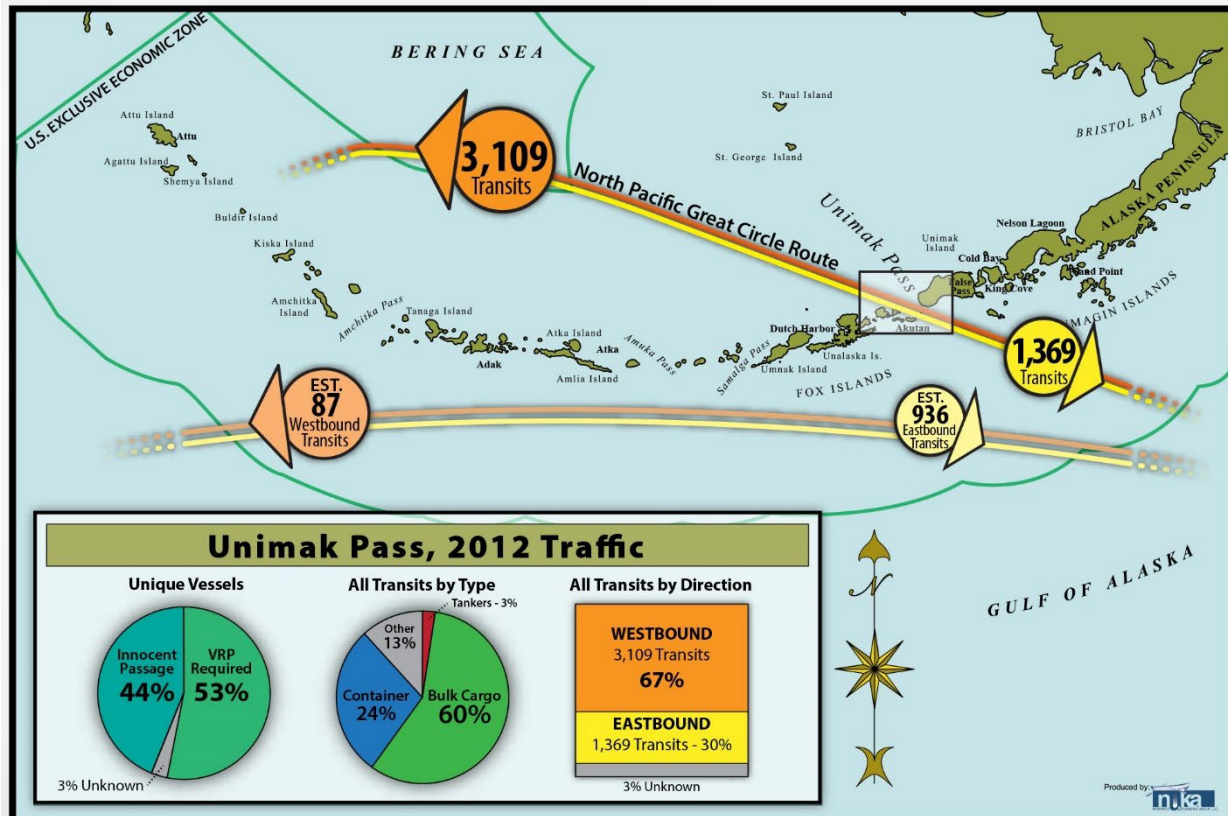


Figure 62. Summary of Unimak Pass traffic recorded in 2012, including percentage of vessels in innocent passage and by vessel type; also includes roughly estimated transits south of the island chain based on number of vessels going through Unimak Pass (Nuka Research and Planning Group 2015).

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). Small recreational vessels traveling at speeds over 13 kt were most commonly involved in ship strike encounters; however, all types and sizes of vessels were reported (Neilson et al. 2012b). The majority of vessel strikes involved humpback whales (93 whales; 86 percent) and the number of humpback strikes increased annually by 5.8 percent from 1978 to 2011 (Neilson et al. 2012b). During the same time period, three fin whales, one gray whale, one sperm whale, and six unidentified whales were reported (Neilson et al. 2012b). In more recent years (2012–2022), reported strikes in Alaska include 58 humpback whales, four fin whales, and two sperm whales (Helker et al. 2019; Freed et al. 2023; Brower et al. 2024a). There were also nine reported ship strikes of unidentified whales (Helker et al. 2019; Freed et al. 2023; Brower et al. 2024a).

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 63). Oil produced on the western side of Cook Inlet is transported by tankers to the refineries on the east side.

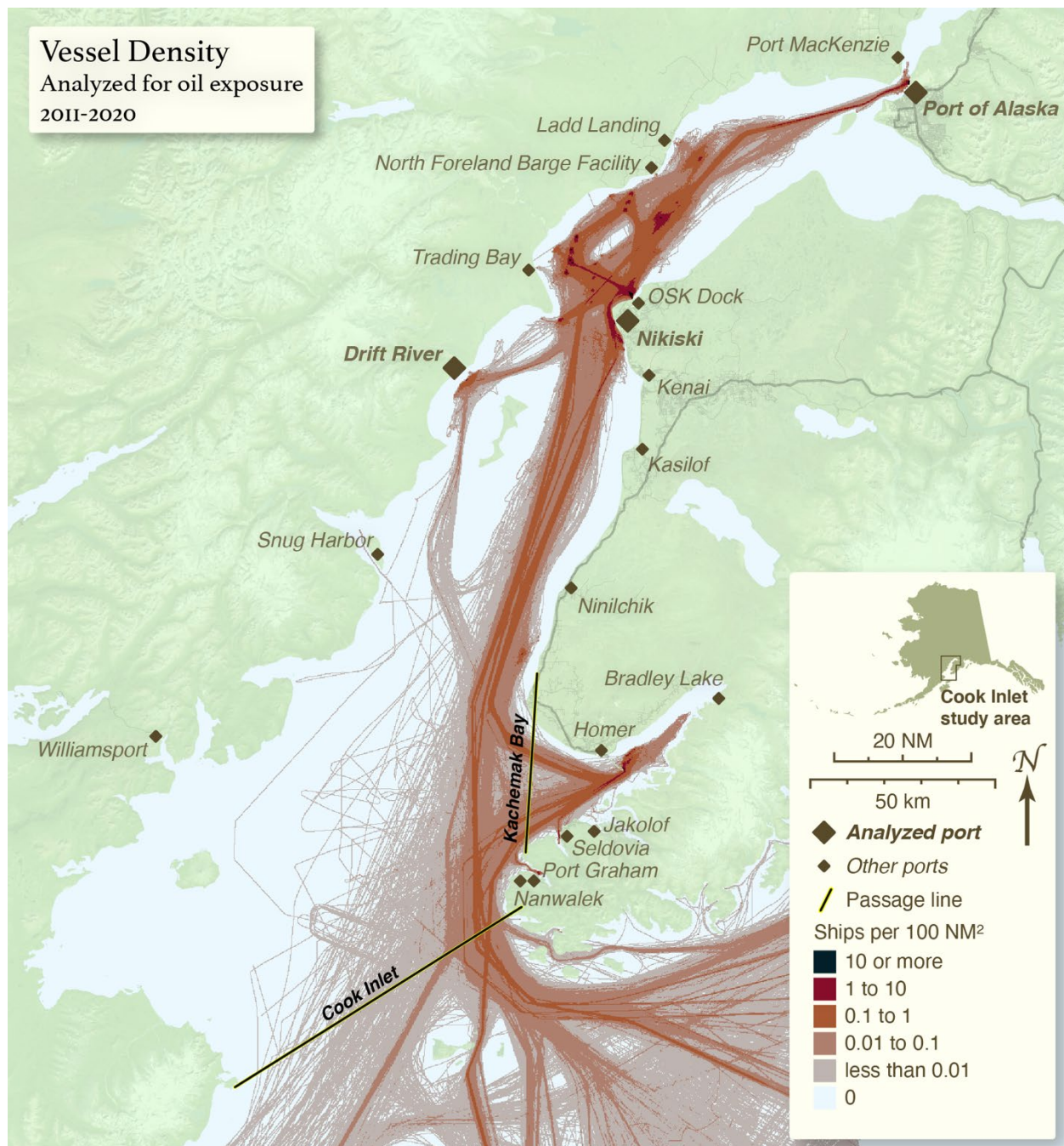


Figure 63. Summary of Cook Inlet vessel density between 2011 and 2020 (Research 2022)

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 (2003a) 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).

Cook Inlet belugas may be affected by the sounds associated with shipping and transportation. There are anecdotal reports of Cook Inlet belugas having varying reactions to vessel traffic; observers recorded diving, direction changes, and groups splitting when vessels and whales crossed paths in close proximity (HDR 2015 unpublished data). During other observations, beluga behavior suggested no reactions and possible habituation to the vessels. Blackwell and Greene (2003b) speculated belugas may habituate and become tolerant of vessels in areas subjected to perennial boat traffic.

Belugas may also decrease or cease vocalizations in response to sounds from ships and other activities, or their vocalizations may be masked (Castellote et al. 2016; Castellote et al. 2018b). Scheifele et al. (2005) found that shipping noise caused belugas to vocalize louder. Lesage et al. (1999) described more persistent vocal responses when whales were exposed to a ferry as opposed to a small-boat, including a progressive reduction in calling rate while vessels were approaching, an increase in the repetition of specific calls, and a shift to higher frequency bands when vessels were close to the whales. Brewer et al. (2023) found that the most common call types of Cook Inlet belugas were partially masked by distant commercial ship noise and completely masked by close commercial ship noise in the frequency range up to 12 kHz. Belugas altering their vocal behavior is indicative of an increase in energy costs, and long-term adverse energetic consequences could occur, if noise exposure is chronic. The degradation of the beluga acoustic communication and echolocation space, as well as the noise-induced chronic increase of signaling costs and stress, could lead to negative biological consequences at the population level (NMFS 2016c).

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 2017b). Some baleen whales have adjusted their communication frequencies, intensity, and call rate to limit masking effects from anthropogenic sounds such as shipping traffic. Baleen whales may also exhibit behavioral changes in response to vessel noise. Marine mammals that have been disturbed by anthropogenic noise and vessel approaches are commonly reported to shift from resting behavioral states to active behavioral states, suggesting an energetic cost to the affected animal. Humpback cow-calf pairs significantly reduced the amount of time spent resting and milling when vessels approached, as compared to undisturbed whales (Morete et al. 2007). Responding to vessels is

likely stressful to humpback whales, but the biological significance of that stress is unknown (Bauer and Herman 1986).

Potential impacts of vessel disturbance on Steller sea lions have not been well studied, and the responses likely depend on the season and stage in the reproductive cycle (NMFS 2008d). Steller sea lions are more likely to be disturbed at haulouts and near rookeries, where in-air vessel noise or visual presence could cause behavioral responses such as avoidance of the sound source, spatial displacement from the immediate surrounding area, trampling, and abandonment of pups (Calkins and Pitcher 1982; Kucey 2005). Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles (NMFS 2008d). Increases in ambient noise from vessel traffic, however temporary, also have the potential to mask communication between sea lions and affect their ability to detect predators (Richardson and Malme 1993c; Weilgart 2007a).

5.4.3.2 Vessel Strikes

Cook Inlet beluga whales are susceptible to vessel strike mortality. In an examination of 106 individuals, 14 percent had signs of confirmed or possible vessel strike (McGuire et al. 2020c). Beluga whales may be more susceptible to strikes from commercial and recreational fishing vessels (as opposed to cargo ships, oil tankers, and barges) because 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.

From 1978-2011, there were at least 108 recorded whale-vessel collisions in Alaska, with the majority involving humpback whales and occurring in Southeast Alaska (Neilson et al. 2012b). Between 2013 and 2021, 47 humpback whales were struck resulting in 22.12 mortalities or serious injuries in Alaska (Delean et al. 2020; Freed et al. 2022; Freed et al. 2023). Five fin whales were struck and killed between 2013 and 2021 (Delean et al. 2020; Freed et al. 2022; Freed et al. 2023).

There have been three documented large cetacean vessel collisions in Cook Inlet since 2001; one fin whale, one humpback whale, and one unidentified large cetacean. In 2001, a humpback whale was discovered on the bulbous bow of a 216 m container ship as it docked in the POA. In 2005, a 8.5 m charter boat hit an unidentified large cetacean, and a dead fin whale was discovered on the bulbous bow of a ship at the POA. The low number of fin and humpback whales in upper and middle Cook Inlet greatly reduces the probability of vessel strike in this area.

Although 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 2008d). In 2007, a Steller sea lion with two separate wounds consistent with blunt trauma that may have been from a vessel strike was found in Kachemak Bay. A vessel strike of a Steller sea lion is highly unlikely to occur due to their maneuverability, low numbers in upper and middle Cook Inlet, and the slow transit speeds of the project vessels.

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 (Sullivan 1980; Allen 1984; Henry and Hammill 2001; Edrén et al. 2010; London et al. 2012). 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 (Parks 2003; McDonald et al. 2006; 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 2011a). 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 1 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 2013c)). 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 Parms.

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 2018c). 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

Many of the consultations have analyzed the take (by harassment) of listed species from sounds produced during geophysical (including seismic) surveys and drilling operations conducted by leaseholders during open water (i.e., summer) months. Geophysical seismic survey activity has been described as one of the loudest man-made underwater sound sources, with the potential to harass or harm marine mammals (Richardson et al. 1995b). Controlled-source, deep-penetration reflection seismology, similar to sonar and echolocation, is the primary tool used for onshore and offshore oil exploration (Smith et al. 2017). Seismic surveys are conducted by towing long arrays of sensors affixed to wires at approximately 10 knots behind large vessels following a survey grid. High power air cannons are fired below the water surface, and the sound waves propagate through the water and miles into the seafloor. When those soundwaves encounter strong impedance contrasts (e.g., between water and the ocean floor, or between different densities of substrates), a reflection signal is detected by the sensors. Those signals can be interpreted to determine the stratigraphy of the substrate and identify oil and gas deposits.

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 Richardson 1988; Greene and Moore 1995). 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, it strongly supports sound propagation in the 50 to 500 Hz frequency band (Funk et al. 2008). The sound generated from seismic surveys has been linked to behavioral disturbance of wildlife and potential auditory injury to marine mammals in the marine environment (Smith et al. 2017). Seismic surveys are often accompanied 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.

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.

5.5.1.4 Aircraft

The sound and visual presence of aircraft can result in behavioral changes in whales such as diving, altering course, vigorous swimming, and breaching (Patenaude et al. 2002b). Oil and gas development projects often involve helicopters and fixed-winged aircraft, and aircraft are used for surveys of natural resources. 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. 1995b). Richardson et al. (1995b) and Richardson and Malme (1993b) observed that bowhead whales in the Beaufort Sea will dive or swim away when low-flying (500 m (1640 ft)) aircraft pass above them.

Ringed seals departed their lairs in response to a helicopter flying 5 km from the lair, and during helicopter landings and take-offs as far away as 3 km (Kelly et al. 1988). They are most adversely affected by noise disturbance in late March through June when they spend greater amounts of time out of the water and their movements are limited to small areas due to their dependent offspring (Kelly et al. 1988). One study indicated that the risk of scaring ringed seals into the water can be substantially reduced if small-type helicopters do not approach closer than 1500 m and small fixed-wing aircraft do not approach closer than 500 m (Born et al. 1999).

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 (Burgess 2014; BOEM 2016a).

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 2003a; 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 two sightings of beluga whales (4 individuals), and one 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

NMFS completed formal consultation in 2017 for Furie Operating Alaska (Furie) to conduct oil and gas exploratory drilling operations in the Kitchen Lights Unit in upper Cook Inlet between 2017 and 2021 (NMFS 2017a). Actions included tugs towing a jack-up rig from winter storage in lower Cook Inlet to the drilling sites, high-resolution geophysical surveys, pile driving at the drilling locations, drilling operations, vessel and air traffic associated with rig operations, fuel storage, and well completion activities. Furie did not conduct exploratory drilling in 2017 and requested reinitiation in late 2017 after modifying the proposed actions. NMFS completed an informal consultation on the updated action, concurring that the action was not likely to adversely affect listed species or critical habitat, and no take was authorized (NMFS 2018d). PSOs monitored during pile driving in June 2018 and observed one beluga carcass unrelated to project activities (Jacobs Engineering Group 2019). The Kitchen Lights Unit was purchased by HEX, LLC at a December 2019 bankruptcy auction.

Furie submitted an application for two IHAs to the NMFS Permits Division in July 2023 for oil and gas exploration, development, and production activities in Cook Inlet from April 1, 2024, to November 15, 2025. The application included production drilling at existing platforms in middle Cook Inlet using a jack-up rig towed by tugs. Furie plans to drill one new grassroots well in one of the two well slots in which a conductor pipe is expected to be installed via pile driving in Year 1 and plans to drill one sidetrack well in Year 2.

Hilcorp Oil and Gas

The Hilcorp Incidental Take Regulations issued in 2019 included oil and gas exploration, development, production, and decommissioning activities in Cook Inlet between 2019 and 2024. As discussed above, Hilcorp completed seismic operations in 2019. Hilcorp completed routine pipeline maintenance operations in 2020 and did not observe any marine mammals. In 2021, three tugs transported the *Spartan 151* jack-up rig for plug and abandonment activities and production drilling. Hilcorp also completed a shallow hazard survey over lower Cook Inlet Outer Continental Shelf leases in 2021 to evaluate potential hazards, document any potential cultural resources, identify shallow hazards, obtain engineering data for placement of structures, and detect subsurface geologic hazards.

Hilcorp transported the jack-up rig from the Rig Tender's Dock in Nikiski to the Tyonek platform in middle Cook Inlet in June 2022 and back to the dock in September 2022. In 2023, Hilcorp transported the jack-up rig from the Rig Tender's Dock to the subsea Well Site 17589 in June, to the Tyonek platform in July, and back to the dock in November.

Hilcorp and Harvest also received a Letter of Concurrence from NMFS AKR in 2022 for routine oil and gas pipeline and infrastructure maintenance. Routine maintenance activities include: subsea pipeline inspections, pipeline stabilization, and repair and replacement; platform leg inspections and repairs; and, anode sled installations. Work under the informal consultation will occur over a five-year period from 2022 – 2027.

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 64). 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).

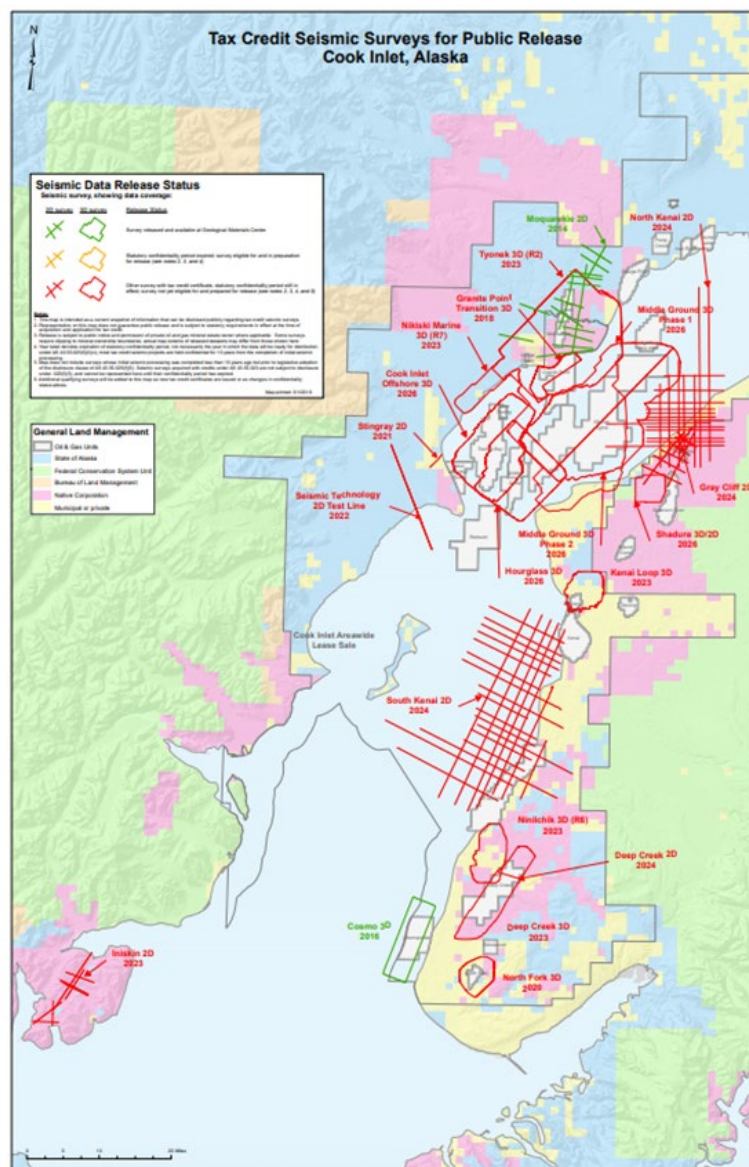


Figure 64. Seismic surveys in Cook Inlet. Dates indicate year technical data is scheduled for release.

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 $\geq 160 \text{ dB}_{\text{RMS}}$ and 4 at $\geq 180 \text{ dB}_{\text{RMS}}$) (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. 2015a).

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 59). 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 39.

Table 39. 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
^a One sighting equals one group. ^b Totals do not include re-sightings. ^c Includes both Western North Pacific and Mexico DPS. ^d Based 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 2017c).

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 (USACE-DOER 2001; URS 2007).

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.

5.5.2.5 Military Detonations

NMFS consulted on winter live-fire weapons training on the Eagle River Flats (ERF) Impact Area at Joint Base Elmendorf-Richardson (JBER) in 2016. Live-fire training uses firing positions on a designated range facility, at predetermined targets, in a controlled access area known as an impact area. ERF has been used as a dudded impact area since about 1945. A dudded impact area is an area having designated boundaries within which all dud producing ordnance will detonate on impact. This area may include vehicle bodies that serve as targets for artillery/mortar direct and indirect fire. The current winter-only firing restriction have been in place since 1991.

Cook Inlet beluga whales may be able to hear sounds from JBER while they are in coastal waters near the firing range; however, NMFS determined that low frequency impulses from exploding ordnance are not expected to cause noise levels of concern. Adverse effects are extremely unlikely because belugas are not expected to be present in the winter when firing occurs, no measurable effects on their prey base are expected, and mitigation measures are in place to further lessen the chances of any take by harassment. JBER measured the acoustic propagation and developed buffer zones to ensure sound that reaches Eagle Bay falls below 160 dB_{rms} re 1 μPa, the Level B take threshold for non-continuous sound for cetaceans. NMFS concluded that acoustic effects on belugas associated with the action were extremely unlikely to occur.

5.5.2.6 Aircraft Noise

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.

The responsiveness of baleen whales (i.e., fin and humpbacks) to aircraft is also variable and may depend on behavioral state, habitat, and age class of the animal. Responses include diving and turning, as well as other changes in behavior. Whales actively engaged in feeding or social behavior often appear less sensitive, and typically do not exhibit a reaction. Whales with calves or in confined waters may be more sensitive. Single or occasional aircraft overflights do not seem to cause long-term displacement or abandonment by whales (Richardson et al. 1995).

Aircraft may also disturb Steller sea lions, especially if hauled out. Disturbance of a rookery or haulout has the potential to result in serious injury or death, predominantly from trampling. Over 1,000 sea lions were observed stampeding off a beach in response to a large helicopter over a mile away (Withrow 1982). There are no major rookeries or haulouts within Cook Inlet.

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 2016d). 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. 2010a). 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 2017c).

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 2017c).

In the past 30 years, 43 wells have been drilled in the Beaufort and Chukchi seas 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. On average, approximately 2,000 oil and hazardous substance spills are reported to the Alaska Department of Environmental Conservation (DEC) every year.³⁹ Most were in nearshore and shallow coastal waters and were primarily diesel (BLM 2019). Only one percent of the spills were crude oil. If a marine mammal came in direct contact with a small, refined oil spill it could experience inhalation and respiratory distress from hydrocarbon vapors, or ingestion directly or indirectly by consuming contaminated prey, and less likely skin and conjunctive tissue irritation (Engelhardt 1987). Certain marine mammals may also be prone to fouling of pelage by oil, which may subsequently be ingested during grooming or cleaning. Small offshore spills of refined petroleum products are expected to dissipate rapidly. A small spill could impact marine mammals through their ingestion of contaminated prey, but prey contamination likely will be localized and temporary.

³⁹ <https://dec.alaska.gov/spar/ppr/response-resources/local-response>, viewed 12/19/2023

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 2017d).

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 2017d).

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 2017d). From 1964 to 2010 there were 283 well control incidents, 61 of which resulted in crude or condensate spills (BOEM 2012; BOEM 2017d). 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 2017d). 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 2017d).

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 2017d).

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 2017d).

Marine mammals can ingest spilled compounds while feeding, inhale the volatile components, or be affected by direct contact. Effects of oil ingestion on marine mammals can range from progressive organ damage to death, depending on the quantity and composition of the ingested oil (Geraci and St. Aubin 1990). The effects of an oil spill on marine mammals would depend largely on the size, season, and location of the spill. Surface contact with oil spills can damage mucous membranes and eyes of seals, or disrupt thermoregulation in seal pups (Geraci and St. Aubin 1990). If a spill were to occur during the ice free, open water season, seals may be exposed to oil through direct contact, or perhaps through contaminated food items. However, St. Aubin (1990) notes that with their keen olfaction and good vision, seals may be able to detect and avoid oil spills in the open water season (St. Aubin 1990).

Immersion studies by Geraci and Smith (1976) found ringed seals may develop mild liver injury, kidney lesions, and eye injury from immersion in crude oil. The eye damage was often severe, suggesting permanent eye damage might occur with longer periods of exposure to crude oil, and the overall severity of the injuries was most likely associated with the exposure duration to crude oil. Geraci and Smith (1976) concluded the direct effects of an oil blow-out or spill may result in transient eye damage to healthy seals in open water; however, ringed seals exposed to a slick of crude oil showed no impairment in locomotion or breathing.

If marine mammals have encountered any of the spills that have occurred in their habitat, these encounters have not been documented. The small size of the spills and the dispersive action of waves and currents likely has reduced the probability of an encounter and adverse reaction to extremely low levels. While the potential for a large spill exists, and could have devastating effects on marine mammals we have no evidence that the spills that have occurred are negatively affecting marine mammals at this time.

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. 2010c).

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. Changing environmental conditions have 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.

Lee et al. (1996) compared persistent organochlorine pesticides and PCBs in Steller sea lions in the Gulf of Alaska to Steller sea lions in the Russian waters of the Bering Sea. PCBs were the predominant organochlorine in Steller sea lion blubber, followed by DDT. The level of PCBs in male Steller sea lions were higher than those in ringed seals in Arctic waters. Steller sea lions in the Bering Sea had significantly lower DDTs and PCBs than those from the Gulf of Alaska (Lee et al. 1996). Ferdinando (2019) assessed heavy metals in marine mammals including Steller sea lions. In the southwest Alaska area consisting of the Aleutian Islands, mercury was the highest concentration of heavy metal found in Steller sea lions, followed by lead, nickel, and copper and were concentrated in the fur, tendon, and muscle tissues (Ferdinando 2019).

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 2016d) 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 2008b; 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 2008b). 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 (NMFS 2008b; EPA 2015). 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 2010a). 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 2008b). 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 1991b). 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 Database⁴⁰ 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

⁴⁰ <https://dec.alaska.gov/spar/ppr/spill-information/spill-data/> Accessed May 20, 2020.

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).

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 the creation of traditional handicrafts, provided neither is accomplished in a wasteful manner.

Whaling by Alaska Natives in the Alaskan Arctic and sub-arctic has taken place for at least 2,000 years (Marquette and Bockstoe 1980; Stoker and Krupnik 1993). Subsistence harvest has been regulated by quotas set by the International Whaling Commission (IWC) and allocated by the Alaska Eskimo Whaling Commission since 1977. Alaska Native subsistence whalers from 11

Alaska communities take approximately 0.1 to 0.5 percent of the population per annum (Philo et al. 1993a; Suydam et al. 2011a; Suydam and George 2020). The catch/strike limit per year is set by a quota which is determined by the IWC based on subsistence needs and bowhead whale abundance and trend estimates (Young et al. 2024b). From 1974 to 2023, a total of 1,493 bowhead whales were landed by hunters from 12 villages in Alaska (a total of 636 bowheads were landed in Alaska during 2010–2023 Table 40), with Barrow landing the most whales ($n = 748$) and Little Diomed and Shaktoolik landing the least, with only two landings and one landing, respectively (Suydam and George 2020; Suydam et al. 2020; Scheimreif et al. 2021; Scheimreif et al. 2022; Scheimreif et al. 2023; Scheimreif et al. 2024). 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. 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 2023, 45 of 55 whales struck were landed, resulting in an efficiency of 82 percent, which was slightly higher than the previous 10-year (2013–2022) average of 79 percent (Scheimreif et al. 2024).

Canadian and Russian Natives also take whales from this stock. No catches of Western Arctic bowhead whales were reported by Canadian hunters between 2017 and 2022. One bowhead whale was landed in Russia in 2017 (Zharikov 2018), none in 2018 (Zharikov et al. 2019), one in 2019 (Zharikov et al. 2020); none in 2020, 2021, or 2022 (Sidorov et al. 2021; Sidorov et al. 2022; Sidorov et al. 2023); and one in 2023 (Sidorov et al. 2024), resulting in an average annual take of 0.4 (landed) whales by Indigenous Russians between 2017 and 2021. The total mean annual subsistence take between 2019 and 2023 is 48 bowhead whales by Alaska Natives (equals the number of landed whales plus the struck and lost mortality; Table 40).

Table 40. 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
2018	47
2019	30
2020	54
2021	57
2022	53
2023	45
(Suydam et al. 2011a; Suydam et al. 2012; Suydam et al. 2013a; Suydam et al. 2014; Suydam et al. 2015; Suydam et al. 2016; Suydam et al. 2017, AEWG unpublished data, 2017; Suydam et al. 2018; Suydam et al. 2019; Suydam et al. 2020; Scheimreiff et al. 2021; Scheimreiff et al. 2022; Scheimreiff et al. 2023; Scheimreiff et al. 2024).	

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 2019). Estimates of subsistence harvest of ringed and bearded seals are available for several of these communities based on annual household surveys (Table 41), but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. From 2012-2017, only four percent (3 of 64) of the coastal communities that harvest ice seals have been surveyed in two or more consecutive years (Ice Seal Committee 2019). 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 2019). From 2013 through 2017, the total annual ringed and bearded seal harvest estimates across surveyed communities ranged from 185 to 1,306 and 114 to 1,176, respectively (Table 41).

Table 41. Alaska ringed and bearded seal harvest estimates based on household surveys, 2013–2017.

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Nuiqsut	-	58	-	-	-	-	26	-	-	-
Utqiagvik	-	428	-	-	-	-	1,070	-	-	-
Point Hope	-	246	-	-	-	-	183	-	-	-
Kotzebue	-	69	-	-	-	-	228	-	-	-
Shishmaref	-	296	-	-	-	-	319	-	-	-
Hooper Bay	667	158	185	546	193	171	64	148	118	114
Tununak	-	-	-	117	-	-	-	-	19	-
Tuntutuliak	75	-	-	-	-	53	-	-	-	-
Quinhagak	160	51	-	26	-	49	16	-	38	-
Total	902	1,306	185	689	193	273	1,176	148	175	114

Source: adapted from Ice Seal Committee (2019). Villages with no landings were not included. This is the most current information available as of June 2025.

5.7.1.2 Stranding

During 2016-2024, 49 stranded bowhead whales were documented within the range of the Western Arctic Stock (Table 42); NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 26 June 2024). In 2024, two bowhead whale carcasses had evidence of human interactions with possible entanglements. One bowhead whale carcass had a single, mono filament line of unknown origin which was probably the cause of the stranding. A second bowhead whale carcass had a green line and possible netting floating near the carcass and draped over the ventral side of the mouth; however, it could not be determined if the gear was the cause of the stranding as only photos were available and it was unclear if the gear was wrapped or attached to the carcass. it could not be determined if the gear observed on one carcass was the cause of the stranding. The cause of death is unknown for most of these reports as only photos were available and the level of decomposition was too advanced.

Table 42. Number of stranded bowhead whales from 2017 to 2021.

Year	Number Stranded Bowheads
2016	6
2017	1
2018	4
2019	16
2020	0
2021	11
2022	1
2023	4
2024	7

The NMFS AKR Stranding Network received reports of many stranded ice seals in spring and summer 2019. NMFS declared an Unusual Mortality Event (UME) for ringed, bearded, and spotted seals. The UME occurred from June 1, 2018, through December 31, 2019, with peak strandings between June 1, 2018, and August 31, 2019. During the event, 284 ice seals stranded—including 97 bearded seals, 75 ringed seals, 48 spotted seals, and 64 seals of unidentified species. Out of the 284 stranded seals, 275 seals were dead and nine seals stranded alive. Only 32 of the stranded seals were adults; the rest were younger age classes (pups, yearlings, or sub-adults). Most dead stranded seals were in moderate to advanced states of decomposition, and the most common finding in examined animals was malnutrition. The Investigative Team and the Working Group on Marine Mammal Unusual Mortality Events concluded that the preliminary cause of the UME was ecosystem changes in the Bering Sea causing impacts on prey availability leading to malnutrition and death observed in stranded seals.

5.7.1.3 Predation

Little is known about the natural mortality of bowhead whales (Philo et al. 1993b). 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. 1993b). Bowhead whales have no known predators except humans and killer whales. Transient killer whales are known to prey on bowhead whales. In a study of marks on bowhead whales taken in the subsistence harvest between spring 1976 and fall 1992, 4.1% to 7.9% had scars indicating that they had survived attacks by killer whales (George et al. 1994). Of 377 complete records for killer whale scars collected from 1990 to 2012, 29 whales (7.9%) had scarring “rake marks” consistent with killer whale injuries and another 10 had possible injuries (George et al. 2017a). A higher rate of killer whale rake mark scars occurred from 2002 to 2012 than in the previous decade. George et al. (2017a) noted this may be due to better reporting and/or sampling bias, an increase in killer whale population size, an increase in occurrence of killer whales at high latitudes (Clarke et al. 2013c), or a longer open water period offering more opportunities to attack bowhead whales. The ASAMM project photo-documented bowhead whale carcasses that had injuries consistent with killer whale predation in 2010 (n = 1), 2012 (n = 2), 2013 (n = 3), 2015 (n = 3), 2016 (n = 4), 2017 (n = 1), 2018 (n = 4), and 2019 (n = 7; Willoughby et al. 2020; Willoughby et al. 2022). Scars from interactions with killer whales were also present on landed whales in 2020 (n = 2), 2021 (n = 3), and 2023 (n = 1), and on two of three carcasses observed during North Slope Borough autumn aerial surveys conducted in 2021, as well as on four carcasses documented in 2023 (Stimmelmayer et al. 2022; Stimmelmayer et al. 2024).

Polar bears are the main predator of ringed and bearded seals (Cameron et al. 2010a; Kelly et al. 2010b). Other predators of both species include walruses and killer whales (Burns and Eley 1976; Heptner et al. 1976; Fay et al. 1990; Derocher et al. 2004; Melnikov and Zagrebin 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 (Smith 1976; Kelly et al. 1986; Lydersen et al. 1987; Lydersen and Smith 1989; Lydersen 1998). 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. 2010a; Kelly et al. 2010b).

Polar bear predation on ringed seal pups tripled when pups were prematurely exposed as a consequence of unseasonably warm conditions. Hammill and Smith (1991) further noted that polar bear predation on ringed seal pups increased four-fold when average snow depths in their study area decreased from 23 cm to 10 cm. Gulls, ravens, and possibly snowy owls prey on ringed seal pups when the latter are forced out of subnivean lairs prematurely because of low snow accumulation and/or early melts (Lydersen et al. 1987; Lydersen and Smith 1989; Lydersen and Ryg 1990; Lydersen 1998). Avian predation is facilitated not only by lack of sufficient snow cover but also by conditions favoring influxes of birds (Kelly et al. 2010b).

5.7.2 Cook Inlet

5.7.2.1 Subsistence Harvest

Subsistence harvest of Western DPS Steller sea lions is regulated by co-management agreements with NMFS, and occurs at or well below sustainable levels of harvest. Annual statewide data on community subsistence harvest of Steller sea lions are no longer collected as of 2009; therefore, the best available statewide subsistence harvest estimates for Western DPS Steller sea lions are those from 2004 to 2008. The mean annual subsistence take (harvested plus struck-and-lost) from the Western DPS from 2004 through 2008, combined with the mean annual take between 2014-2018 from St. Paul, St. George, and Atka Island, was 209 sea lions per year (Muto et al. 2021).

With the exception of the harvest of bowhead whales by subsistence hunters in the Alaska Eskimo Whaling Commission's 11 member villages, subsistence hunters in Alaska are not authorized to take any species of great whales, which includes fin and humpback whales, under the Whaling Convention Act (16 USC § 916 et seq.). However, one humpback whale was unlawfully harvested in Kotlik in October 2006, and another in Toksook Bay in May 2016.

Previous Cook Inlet beluga subsistence harvests had a significant effect on the population. While an unknown amount of harvest occurred for decades or longer, the subsistence harvest increased substantially to unsustainable levels in the 1980s and 1990s. Harvests from 1994 to 1998 likely account for the population decline during that time period. Cook Inlet beluga whale subsistence harvest ceased in 1999 as a result of both a voluntary moratorium by the hunters and passage of Public Law 106–31, section 3022 (later made permanent by Public Law 106-553, section 627), which required any taking of Cook Inlet beluga whales by Alaska Natives to occur pursuant to a cooperative agreement between NMFS and affected Alaska Native organizations. The law did not specify a harvest level or a harvest management plan. In May 2000, NMFS designated Cook Inlet belugas as a depleted stock under the MMPA (65 FR 34590, May 31, 2000). Subsequently, NMFS promulgated interim harvest regulations that provided a harvest management plan (69 FR 17973, April 6, 2004). The co-management agreement developed pursuant to these regulations allowed the harvest of two whales in 2005 and one whale in 2006; however, no whales were taken in 2006 due to poor weather and the avoidance of females with calves. In 2008, NMFS issued regulations (73 FR 60976, October 15, 2008; 50 CFR § 216.23(f)) 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 Poaching and Illegal Harassment

The potential for poaching beluga whales in Cook Inlet exists due to their distribution within the most densely populated region in Alaska and their approachable nature. NMFS maintains an enforcement presence in upper Cook Inlet; however, effective enforcement across such a large area is difficult. NMFS Enforcement has investigated several reports of Cook Inlet beluga whale harassment, but there have been no confirmed poaching incidents.

Historically, Steller sea lions have been poached and illegally harvested throughout their range. The NMFS Alaska Marine Mammal Stranding Program documented 60 Steller sea lions with suspected or confirmed firearm injuries in Southeast and Southcentral Alaska from 2000–2019 (Wright 2016; Wright 2021). Western DPS Steller sea lions with gunshot wounds have been found stranded on shore along the outer Copper River Delta in recent years (Wright 2016; Wright 2021), and seven of nine pinnipeds stranded in the surveyed area in 2019 were shot (Wright 2021).

There are two known cases of unlawful harvests of humpback whales in Alaska. Subsistence hunters in western Alaska incorrectly believed they could legally harvest large whales other than bowheads (e.g., humpback, gray, and minke whales).

5.7.2.3 Stranding

Cook Inlet beluga whales are likely predisposed to stranding because they breed, feed, and molt in the shallow waters of upper Cook Inlet where extreme tidal fluctuations occur. Strandings may 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. Stranding events that last more than a few hours may result in mortalities. An estimated 876 to 953 live beluga strandings and 214 dead beluga beachings have been documented in Cook Inlet from 1988 through 2015 (NMFS 2016c). Patterns of mortality for the population were analyzed and live stranding was the predominant assigned cause of death; however, this only represented approximately 33 percent of the deaths of known cause (McGuire et al. 2021). Causal factors for the majority of deaths and live strandings are unknown.

An unusually high number of beluga live stranding events occurred in Turnagain Arm in 2003 (Vos and Shelden 2005). The number of animals stranded ranged from two to 46 and led to five confirmed deaths (Vos and Shelden 2005). Stranding is a stressful event and, if the beluga survives, health after the event may be affected. Stranding events may represent a significant threat to the conservation and recovery of this population.

Live strandings are uncommon among sea lions; however, pinniped strandings and mortality resulting from entanglement in fishing gear have been documented (Loughlin and York 2000; Raum-Suryan et al. 2009; Muto et al. 2021).

Nearly all known cases of fin whale and humpback whale strandings involve animals that died at sea of various other causes and washed ashore. A fin whale live stranded and died in upper Knik Arm in June 2016. A young humpback live stranded on the mud in Turnagain Arm in April 2019 and, while it freed itself on an incoming tide at one point, the whale later died.

5.7.2.4 Predation

Killer whales are the only natural predators of beluga whales and Steller sea lions in Cook Inlet (Muto et al. 2021). Killer whale sightings were not well-documented prior to the mid-1980s and were likely rare in the upper Inlet. Alaska Native beluga hunters reported that killer whales were rarely seen in the upper Inlet or near belugas (Huntington 2000). Sightings from systematic surveys, observer databases, and anecdotal accounts from 1975 to 2002 were compiled, and there were only 18 documented sightings north of Kalgin Island (Shelden et al. 2003). Killer whales were not observed in upper Cook Inlet during approximately 4,000 hours of land- and vessel-based surveys conducted from 2005 to 2017, and there were no scars consistent with killer whale attacks in the photographs taken during these surveys (McGuire et al. 2020c). Monitoring efforts during the POA PCT construction project detected two transient killer whales in Knik Arm in September 2021. Two to three killer whales were observed in close proximity to belugas in Knik Arm near Cairn Point in September 2023.

Prior to 2000, it was estimated that an average of one Cook Inlet beluga whale was killed by killer whales annually (Shelden et al. 2003). From 1982-2014, between 9 and 12 beluga whale deaths were suspected to be a direct result of killer whale predation (NMFS 2016c). NMFS received no reports of possible predation attempts in Cook Inlet from 2011 through 2020; however, killer whales have been visually and acoustically detected in the area during this time (61 North Environmental 2022a; Castellote et al. 2023).

The risk to Western DPS Steller sea lions from killer whale predation is considered potentially high (Muto et al. 2021), and may be one of the causes contributing to population declines in areas outside of Cook Inlet (Barrett-Lennard et al. 1995). An unsuccessful killer whale attack on a humpback whale was recorded in lower Cook Inlet in 2008 (Matkin 2011). The numbers of fin whales, humpback whales, and Steller sea lions are low in Cook Inlet and any isolated predation event that may occur would not have a population level effect.

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 2019a).

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

Scientific research and enhancement permits that authorize take of ESA listed marine mammals are issued as joint permits under section 104 of the MMPA and section 10(a)(1)(A) of the ESA. From 2017 through 2021, 11 MMPA/ESA research and enhancement permits authorized take of Cook Inlet beluga whales. In 2019, the Office of Protected Resources completed a programmatic biological opinion, which analyzed research impacts on endangered cetaceans; proposed research efforts on endangered or threatened cetacean populations were thought unlikely to cause a change in abundance or reproduction (NMFS 2019b).

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 to collect data on dive behavior and movement within the inlet (Hobbs et al. 2005). In 2002, one of the belugas was found dead 32 hours after being tagged. Another two tagged beluga whales, with similar dive patterns and tagged in the same manner as the deceased whale, transmitted data for less than 48 hours; it is unknown if these

whales also perished or were fitted with defective tags (NMFS, unpublished data). The Marine Mammal Laboratory, a division of NOAA Fisheries' Alaska Fisheries Science Center, began boat-based surveys in 2017 to collect skin and blubber biopsy samples from belugas. A large number of analyses are conducted with the samples, including vital rates (e.g., age and sex), contaminant burdens, diet composition, and health assessments (e.g., cortisol levels).

The Marine Mammal Laboratory also began a boat-based unmanned aircraft systems photogrammetry project in 2017. The project collects imagery, which will be used to estimate age class and an index of beluga calf production,⁴¹ as well as to develop abundance estimates of the population.⁴²

The Cook Inlet beluga whale photo identification project identified many of the tagged belugas; five of the 14 tagged whales in the photo-id catalog had visible signs of tag-site infection, eight had signs of concavity of the dorsal crest above the tag site, and two showed damage to the left pectoral fins, likely caused by flipper bands applied during tagging (McGuire and Stephens 2016). In 2015, a previously tagged whale washed up dead with a significant infection at the tag attachment site, potentially the cause of death. Another whale photographed with serious infection at the tag site has not been documented since 2007 (McGuire and Stephens 2016). It is unlikely that this type of project will be repeated and future research will focus on minimally invasive techniques.

It has been suggested that an increase in the authorized number of Cook Inlet beluga whale takes projected to occur through 2025 is statistically correlated with the decreasing population size (Migura and Bollini 2022). However, 99 percent of the total authorized take in any year are for non-invasive methods, such as photo-identification during vessel surveys. When permitted researchers approach animals closer than the NMFS wildlife viewing guideline distances,⁴³ it is counted as a "take" because those animals may be harassed by the activities. The potential impacts from these research methods are ephemeral harassment at worst. The programmatic biological opinion prepared for NMFS' cetacean research and enhancement permitting program (NMFS 2019b) mentioned above, determined that these methods (e.g., aerial and vessel surveys) are not likely to adversely affect any ESA-listed populations or species, including Cook Inlet beluga whales.

The number of authorized research takes is typically significantly larger than the number of actual takes that occur. For example, 22,090 takes were authorized for Cook Inlet beluga research occurring in 2019; 2,405 takes mostly by harassment occurred. Managers have simplified how take numbers in research permits are determined, in order to provide a more consistent approach to counting take across incidental and directed take permitting programs. NMFS Permits Division continues to closely analyze the number of takes requested and used by researchers each year.

⁴¹ <https://www.fisheries.noaa.gov/alaska/2018-cook-inlet-beluga-aerial-photogrammetry>. Accessed July 2024.

⁴² <https://www.fisheries.noaa.gov/feature-story/noaa-fisheries-delay-new-aerial-survey-cook-inlet-beluga-whales-until-june-2025>. Accessed July 2024.

⁴³ <https://www.fisheries.noaa.gov/topic/marine-life-viewing-guidelines/guidelines-&-distances> Accessed April 2024.

In addition to research activities involving free-ranging Cook Inlet belugas, a single whale from the population is housed in captivity. “Tyonek” live-stranded near Trading Bay as a young calf in 2017. The Alaska Sealife Center and partners provided rehabilitative care; however, the animal was determined to be non-releasable due to underlying medical problems. Pursuant to a scientific research and enhancement permit, which includes an educational component, Tyonek is permanently located at SeaWorld San Antonio, Texas. This is a unique incident, and there are no plans to house additional Cook Inlet beluga whales in captivity.

With the low occurrence of fin whales, humpback whales, and Steller sea lions in upper and middle Cook Inlet, this area is not a high priority for research of these species. However, they may be indirectly affected or harassed by other non-invasive research projects, such as the Cook Inlet beluga aerial surveys. Aircraft may disturb Steller sea lions, especially if hauled out. Disturbance of a rookery or haulout has the potential to result in serious injury or death, predominantly from trampling. However, there are no major rookeries or haulouts within Cook Inlet, and NMFS has no knowledge of any stampedes associated with research in the action area. Also, there have been no known instances of research-related deaths of fin or humpback whales in the action area.

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

5.9 Tourism

Tourism impacts for this opinion are mainly felt in the Cook Inlet portion. While there are no commercial whale-watching companies operating in upper Cook Inlet, aerial tours, such as guided hunting trips, may affect belugas by flying at low altitudes or circling the whales. NMFS has conducted outreach to local pilots and encouraged them to maintain an altitude of 457 m or higher over belugas and to avoid circling over the animals.

Tourism continues to grow in lower Cook Inlet, and a number of commercial vessel-based tour companies operate primarily out of Homer. The tour vessels range in size and capacity from six to over 100 passengers, and include fishing and wildlife viewing tours. There are also a number of commercial flight-seeing tour operators based in Homer. Flights occur over land on the Kenai Peninsula, the waters of lower Cook Inlet (Kachemak Bay), and across the Inlet to places such as Katmai National Park and McNeil River State Game refuge. Aircraft have the potential to disturb marine mammals, particularly pinnipeds hauled out.

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 aims to minimize the likelihood of false negative conclusions (i.e., 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.

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 and habitat alteration from pile driving, dredging, screeding, trenching, and pipelaying activities and placement of equipment or anchors;
5. aircraft noise;
6. pollution from authorized and unauthorized spills;
7. introduction of invasive species from vessels;
8. entanglement and ingestion of trash and debris; and
9. noise effects on prey.

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, WDPS Steller sea lions, 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 species 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 sex 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. 8 Star Alaska 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 analyses presented below, 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.

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 0 above, the NMFS Permits Division and FERC proposed mitigation measures that 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 (Miller et al. 2000; Frstrup et al. 2003), 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. (1995a). More recent reviews (Nowacek et al. 2007; Southall et al. 2007; Southall et al. 2009; Ellison et al. 2012) 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. 1995a; Southall et al. 2007). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995a), 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 (Curry and Edwards 1998; Cowan and Curry 2002; Herráez et al. 2007; Cowan and Curry 2008). Mammalian stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Romero et al. 2008).

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 (Erbe 2002; Williams et al. 2002; Bain et al. 2006; Noren et al. 2009; Pirodda et al. 2015). 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 (NRC 2003a; NMFS 2006).

We expect that project activities may result in animals' experiencing masking of communications, and exhibiting behavioral responses. Therefore, we expect ESA-listed whales and seals may experience stress responses. If whales 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 Major Stressors on 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 has developed comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary thresholds shifts (PTS and TTS) (89 FR 84872; October 24, 2024, 83 FR 28824; June 21, 2018; 81 FR 51693; August 4, 2016). 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,⁴⁴ expressed in root mean square⁴⁵ (rms), from broadband sounds that cause behavioral disturbance, and referred to as

⁴⁴ 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 .

⁴⁵ Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

Level B harassment under section 3(18)(A)(ii) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1362(18)(A)(ii)):

- impulsive sound: 160 dB_{rms} re 1 µPa
- non-impulsive sound: 120 dB_{rms} re 1 µPa

Under the Auditory Injury (AUD INJ)/TTS Technical Guidance, NMFS uses the following thresholds (Table 43) 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 2024a). Different thresholds and auditory weighting functions are provided for different marine mammal hearing groups, which are defined in the Technical Guidance (NMFS 2024). The generalized hearing range for each hearing group is in Table 44. 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 spreadsheet⁴⁶ associated with NMFS Acoustic Guidance or through modeling.

⁴⁶ The Optional User Spreadsheet can be downloaded from the following website:
<http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm>

Table 43. PTS Onset Acoustic Thresholds for Level A Harassment (NMFS 2024).

Hearing Group	Auditory Injury Onset Criteria ¹ (Received Level)	
	Impulsive	Non-impulsive
Underwater		
Low-Frequency (LF) Cetaceans	<i>L_p</i> ,0-pk,flat: 222 dB <i>LE_p</i> , LF,24h: 183 dB	<i>LE</i> ,LF,24h: 197 dB
High-Frequency (HF) Cetaceans	<i>L_p</i> ,0-pk,flat: 230 dB <i>LE_p</i> ,HF,24h: 193 dB	<i>LE</i> ,HF,24h: 201 dB
Very High-Frequency (VHF) Cetaceans	<i>L_p</i> ,0-pk,flat: 202 dB <i>LE_p</i> ,VHF,24h: 159 dB	<i>LE</i> ,VHF,24h: 181 dB
Phocid Pinnipeds (PW) (Underwater)	<i>L_p</i> ,0-pk,flat: 223 dB <i>LE_p</i> ,PW,24h: 183 dB	<i>LE</i> ,PW,24h: 195 dB
Otariid Pinnipeds (OW) (Underwater)	<i>L_p</i> ,0-pk,flat: 230 dB <i>LE_p</i> ,OW,24h: 185 dB	<i>LE</i> ,OW,24h: 199 dB
In-Air		
Phocid Pinnipeds (PA)	<i>L_p</i> ,0-pk,flat: 162 dB <i>LE_p</i> ,PA,24h: 140 dB	<i>LE</i> ,PA,24h: 154 dB
Otariid Pinnipeds (OA)	<i>L_p</i> ,0-pk,flat: 177 dB <i>LE_p</i> ,OA,24h: 163 dB	<i>LE</i> ,OA,24h: 177 dB

¹ Dual metric criteria for impulsive sounds: Use whichever criteria results in the larger isopleth for calculating AUD INJ onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level criteria associated with impulsive sounds, the PK SPL criteria are recommended for consideration for non-impulsive sources.

Note: Peak sound pressure level (*L_p*,0-pk) has a reference value of 1 µPa (underwater) and 20 µPa (in air), and weighted cumulative sound exposure level (*LE_p*) has a reference value of 1 µPa2s (underwater) and (20 µPa) 2s (in air). In this Table, criteria are abbreviated to be more reflective of International Organization for Standardization standards (ISO 2017; ISO 2020). The subscript “flat” is being included to indicate peak sound pressure are flat weighted or unweighted within the generalized hearing range of marine mammals underwater (i.e., 7 Hz to 165 kHz) or in air (i.e., 42 Hz to 52 kHz). The subscript associated with cumulative sound exposure level criteria indicates the designated marine mammal auditory weighting function (LF, HF, and VHF cetaceans, and PW, OW, PA, and OA pinnipeds) and that the recommended accumulation period is 24 hours. The weighted cumulative sound exposure level criteria 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 criteria will be exceeded.

Table 44. Underwater marine mammal hearing groups (NMFS 2024).

Hearing Group [^]	ESA-listed Marine Mammals in the Immediate Action Area Associated with Construction Activities	Generalized Hearing Range*
Low-frequency (LF) cetaceans (<i>Baleen whales</i>)	Bowhead whales, Humpbacks, Fins	7 Hz to 36+ kHz
High-frequency (HF) cetaceans (<i>dolphins, toothed whales, beaked whales</i>)	Cook Inlet beluga whales	150 Hz to 160 kHz
Very High-frequency (VHF) cetaceans (<i>true porpoises</i>)	None	200 Hz to 165 kHz
Phocid pinnipeds (PW) (<i>true seals</i>)	Ringed and bearded seals	40 Hz to 90 kHz
Otariid pinnipeds (OW) (<i>sea lions and fur seals</i>)	Western DPS Steller sea lion	60 Hz to 68 kHz
[^] Southall et al. 2019 indicates that as more data become available there may be separate hearing group designations for Very Low-Frequency cetaceans (blue, fin, right, and bowhead whales) and Mid-Frequency cetaceans (sperm, killer, and beaked whales). However, at this point, all baleen whales are part of the LF cetacean hearing group, and sperm, killer, and beaked whales are part of the HF cetacean hearing group. Additionally, recent data indicate that as more data become available for Monachinae seals, separate hearing group designations maybe appropriate for the two phocid subfamilies (Ruscher et al. 2021; Sills et al. 2021). * Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges may not be as broad. Generalized hearing range chosen based on ~65 dB threshold from composite audiogram, previous analysis in NMFS 2018, and/or data from Southall et al. 2007; Southall et al. 2019. Additionally, animals can detect very loud sounds above and below that generalized hearing range. + NMFS is aware that the National Marine Mammal Foundation successfully collected preliminary hearing data on two minke whales during their third field season (2023) in Norway. These data have implications for not only the generalized hearing range for low-frequency cetaceans but also on their weighting function. However, at this time, no official results have been published. Furthermore, a fourth field season (2024) is proposed, where more data will likely be collected. Thus, it is premature for us to propose any changes to our current Updated Technical Guidance. However, mysticete hearing data is identified as a special circumstance that could merit re-evaluating the acoustic criteria in this document. Therefore, we anticipate that once the data from both field seasons are published, it will likely necessitate updating this document (i.e., likely after the data gathered in the summer 2024 field season and associated analysis are published).		

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 spreadsheet⁴⁷ associated with NMFS Acoustic Guidance, or through modeling.

⁴⁷ The Optional User Spreadsheet can be downloaded from the following website:
<http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm>

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_{rms} re 20μPa 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). Exposure to sound capable of causing Level A or Level B harassment under the MMPA often, but not always, constitutes take under the ESA. For the 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 piles, 14-in H piles, and 48-in pipe piles. Source levels for these piles were adopted from California Department of Transportation (CalTrans

2015; Austin et al. 2016; Illingworth & Rodkin 2017; CalTrans 2020) 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 dBA⁴⁸ at 50 ft (15 m) for impact pile driving.

The pile sizes requiring the use of vibratory drivers include 14-in H piles, 19.69-in sheet piles, and 25-in sheet piles. Source levels for these piles were adopted from California Department of Transportation (CalTrans 2015; Austin et al. 2016; Illingworth & Rodkin 2017; CalTrans 2020) who compiled measured SPL data from impact pile driving for pile sizes ranging in diameter from 12 to 96 in.

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 diminish to background levels within less than 3.1 miles (5 km). Transmission loss (TL) is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water depth, water chemistry, and bottom composition topography. The general formula for underwater TL is:

$$TL = B * \text{Log}_{10} (R_1 / R_2),$$

where

TL = transmission loss in dB;

B = transmission loss coefficient;

R₁ = the distance of the modeled SPL from the driven pile; and

R₂ = the distance from the driven pile of the initial measurement.

Absent site-specific acoustical monitoring with differing measured transmission loss, a practical spreading value of 15 is used as the transmission loss coefficient in the above formula. Project and site-specific transmission loss data for 8 Star Alaska's project area in Prudhoe Bay are not available; therefore, the default coefficient of 15 is used to determine the distances to the Level A and Level B harassment thresholds for all pile driving. All Level B harassment isopleths are reported in Table 46.

The ensonified area associated with Level A harassment is more technically challenging to predict due to the need to account for a duration component. Therefore, NMFS developed an optional User Spreadsheet tool to accompany the 2024 Updated Technical Guidance that can be used to relatively simply predict an isopleth distance for use in conjunction with marine mammal

⁴⁸ The 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.

density or occurrence to help predict potential takes. We note that because of some of the assumptions included in the methods underlying this optional tool, we anticipate that the resulting isopleth estimates are typically going to be overestimates of some degree, which may result in an overestimate of potential take by Level A harassment. However, this optional tool offers the best way to estimate isopleth distances when more sophisticated modeling methods are not available or practical. For stationary sources, such as pile driving, the optional User Spreadsheet tool predicts the distance at which, if a marine mammal remained at that distance for the duration of the activity, it would be expected to incur AUD INJ. Inputs used in the optional User Spreadsheet tool and the resulting estimated isopleths, are reported in Table 46.

Note also and as explained above, NMFS used updated guidance to calculate the zone sizes for Level A and Level B zones for pile driving (89 FR 84872; October 24, 2024). Based on this updated guidance, some zones may differ from the 2020 biological opinion.

Table 45 summarizes the stressors, sound source levels, frequencies at which the equipment operates, and the associated reference. Table 46 outlines the parameters used to calculate the acoustic thresholds and the Level A and B zones for each stressor. Table 47 provides the area of ensonification for each Level A and B zone.

Transmission loss (TL) is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water depth, water chemistry, and bottom composition topography. The general formula for underwater TL is:

$$TL = B * \text{Log}_{10} (R_1 / R_2),$$

where

TL = transmission loss in dB;

B = transmission loss coefficient;

R_1 = the distance of the modeled SPL from the driven pile; and

R_2 = the distance from the driven pile of the initial measurement.

Absent site-specific acoustical monitoring with differing measured transmission loss, a practical spreading value of 15 is used as the transmission loss coefficient in the above formula. Project and site-specific transmission loss data for 8 Star Alaska's project area in Prudhoe Bay are not available; therefore, the default coefficient of 15 is used to determine the distances to the Level A and Level B harassment thresholds for all pile driving. All Level B harassment isopleths are reported in Table 46.

The ensonified area associated with Level A harassment is more technically challenging to predict due to the need to account for a duration component. Therefore, NMFS developed an optional User Spreadsheet tool to accompany the 2024 Updated Technical Guidance that can be used to relatively simply predict an isopleth distance for use in conjunction with marine mammal density or occurrence to help predict potential takes. We note that because of some of the assumptions included in the methods underlying this optional tool, we anticipate that the resulting isopleth estimates are typically going to be overestimates of some degree, which may

result in an overestimate of potential take by Level A harassment. However, this optional tool offers the best way to estimate isopleth distances when more sophisticated modeling methods are not available or practical. For stationary sources, such as pile driving, the optional User Spreadsheet tool predicts the distance at which, if a marine mammal remained at that distance for the duration of the activity, it would be expected to incur AUD INJ. Inputs used in the optional User Spreadsheet tool and the resulting estimated isopleths, are reported in Table 46.

Note also and as explained above, NMFS used updated guidance to calculate the zone sizes for Level A and Level B zones for pile driving (89 FR 84872; October 24, 2024). Based on this updated guidance, some zones may differ from the 2020 biological opinion.

Table 45. 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	183 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
Vibratory 14-in H piles	101 dBA at 15 m	150 dB rms at 10 m 165 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 208 dB peak at 10 m 180 dB SEL at 10 m (water depth 5 m)	Range: 100-10,000 Hz Concentration: 24-25 Hz	Airborne: USDOT 2006 Underwater: Caltrans 2020
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
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

Table 46. Summary of stressors, associated sound source levels, parameters used, and calculated distances to Level A and B in Prudhoe Bay.

Activity	User Spreadsheet Parameters				Underwater Level B (m)		Underwater Level A (m)				Airborne Level B (m)	
	Number of piles per day	Duration to drive single pile (min)	Number of strikes per pile	Source Velocity (m/s)	All Marine Mammals		Low Frequency Cetaceans		Phocids		Pinnipeds	
					Impulsive	Non-Impulsive	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive	Sound Level (dB re 20 µPa)	Threshold Distance @ 100dB
11.5-in H piles Impact pile driving	26.09	-	1,000	-	342	-	1,190	-	1,057	-	101 dBA at 15 m	16.8
14-in H piles Impact pile driving	4	-	1,000	-	341	-	341	-	303	-	101 dBA at 15 m	16.8
14-in H piles Vibratory pile driving	8	15	-	-	-	1,000	-	2	-	4	101 dBA at 15 m	16.8
48-in pipe piles Impact pile driving	1.25	-	1,000	-	2,154	-	625	-	555	-	101 dBA at 15 m	16.8
19.69 & 25 in sheet piles Vibratory pile driving	15.24	18.9	-	-	-	4,642	-	23	-	29	81 dB at 100 m	11.2
Ice trenchers (bulldozer) ^a	-	-	-	0.51	-	40	-	-	-	-	64.7 dB at 100 m	1.8
Screeding/Grading Excavators ^a (backhoe)	-	-	-	0.51	-	215	-	-	-	-	78 dBA at 15 m	1.2
^a Take is not anticipated or authorized for these activities in light of shutdown zones required in the mitigation measures (see Section 2.1.2), therefore, they are not included in the exposure estimates below.												

Table 47. Area of Level A and B ensonified 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	4.45	3.51
14-in H piles Impact pile driving	0.37	0.37	0.29
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	67.7	0	0

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 expected to be present in the Prudhoe Bay portion of the action area (bowhead whales, ringed seals, bearded seals). 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 48 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 48) expected to be present in project area by the area ensonified to the Level A and B thresholds (Table 47), multiplied by the number of days it will take to complete each activity (Table 49). 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 48). If pile driving activities are not completed in the open water season, 8 Star Alaska 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. Table 50 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. In addition, the thresholds for airborne sound from all construction activities are less than 20 m. Since there are no haul-out sites near West Dock, we do not anticipate that ringed and bearded seals would be exposed to in-air noise from construction activities in the Prudhoe Bay area.

Table 48. 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	0.634	0.317	0.317	0.634
Bearded seal ^c	0.136	0.068	0.068	0.136
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, 2011-2019 ^b Summer-fall density was estimated to be 50 percent of the winter-spring density (0.634 seals/km²), resulting in a summer-fall density of 0.317 seals/km² (see Section 4.3.3) ^c Density estimates calculated as 21.3 percent of ringed seal density (see Section 4.3.3).				

Table 49. Calculated durations for installation and removal of piles below MLLW in Prudhoe Bay

Pile Type	Number of Piles by Size					Linear Length (ft) Below MLL W	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
^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.							
^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.							
^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.							
^d NA is not applicable – horizontal length not utilized in duration calculations.							

Level A harassment zones are typically smaller than Level B harassment zones. However, in some cases, the calculated Level A harassment isopleth is greater than the calculated Level B harassment isopleth. Calculation of Level A harassment isopleths include a duration component, which in the case of impact pile driving, is estimated through the total number of daily strikes and the associated pulse duration. For a stationary sound source, we assume here that an animal is exposed to all of the strikes expected within a 24-hour period. Calculation of a Level B harassment zone does not include a duration component. Depending on the duration included in the calculation, the calculated Level A harassment isopleths can be larger than the calculated Level B harassment isopleth for the same activity.

8 Star Alaska estimated the number of days it would take for each activity to be completed, for a total of 164 days (Table 49); however, there are only 123 calendar days in the months of July through October when the work is expected to occur. 8 Star Alaska was not able to identify what

activities will occur in the same day (8 Star Alaska has indicated that no two hammers will operate at the same time), but the 164 days overestimates the exposure estimate. Therefore, NMFS determined a more realistic 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, 8 Star Alaska would be able to start work.) Then NMFS accounted for the fact that 8 Star Alaska has indicated that they will only be working 6 days a week. This equals 97 working days. 8 Star Alaska 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 8 Star Alaska 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):

$$[(123 - 10) * (6/7)] + [(61 * 6/7) / 2]$$

$$[113 * 0.86] + [(61 * 0.86) / 2]$$

$$97 + 26 = 123$$

This is a 25 percent reduction in the number of days 8 Star Alaska used in their exposure estimate. Therefore, the take estimates were reduced by 25 percent (Table 50). NMFS believes this results in take estimates based on a more realistic estimate of the number of likely working days.

Table 50. Estimated Level A and B exposures by pile type and species in Prudhoe Bay

Activity	Level B			Level A		
	Bowhead whale	Ringed seal	Bearded seal	Bowhead whale	Ringed seal	Bearded seal
DH4						
Sheet pile (25-in)	41.65	772.54	165.75	0	0.03	0.01
Anchor pile (11.5-in H-pile)	0.06	1.04	0.22	0.68	10.01	2.15
Mooring dolphins (48-in pipe pile)	2.49	46.14	15.73	0.21	4.07	0.75
Spud piles (14-in H pile)	0.64	11.95	2.56	0	0	0
South Bridge Abutment						
Dock face (19.69-in sheet pile)	26.61	493.57	105.88	0	0.02	0
Tailwall (19.69-in sheet pile)	26.61	493.57	105.88	0	0.02	0
Anchor pile (14-in H pile)	0.02	0.12	0.02	0.01	0.09	0.02
North Bridge Abutment						
Dock face (19.69-in sheet pile)	27.76	515.03	110.48	0	0.02	0
Tailwall (19.69-in sheet pile)	19.67	364.81	78.26	0	0.01	0
Anchor pile (14-in H pile)	0.02	0.12	0.02	0.01	0.09	0.02
Barge Bridge						
Mooring dolphins (48-in pipe pile)	1	18.46	6.29	0.08	1.63	0.30
Spud piles (14-in H pile)	0.21	3.98	0.85	0	0	0
Total	146.74	2,721.33	591.89	0.99^b	16	4
25 percent Reduction in Exposure Estimate Total^{ac}	110	2,041	438	0^b	12	3

^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.

^c8 Star Alaska estimated the number of days it would take for each activity to be completed, for a total of 164 days (Table 49), however, there are only 123 days in the months of July through October when the work is expected to occur and work may also occur during the contingency period. Therefore, to provide a more realistic estimate of the number of likely work days, 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, and 4) the contingency period of late February through April.

Cook Inlet Noise Sources and Exposure Estimates

Pile Driving

8 Star Alaska proposes to conduct vibratory pile installation and removal and impact pile installation. Source levels for these activities are based on reviews of measurements of the same or similar types and dimension of piles available in the literature. Source levels for each pile size and activity are presented in Table 51. Source levels for vibratory installation and removal of piles of the same diameter are assumed to be the same.

8 Star Alaska proposes to conduct concurrent pile driving during construction of the combi-wall and coffer cells in the Marine Terminal MOF. When two noise sources have overlapping sound fields, the sources are considered additive and combined using the rules of dB addition. For addition of two concurrent sources, the difference between the two sound source levels is calculated, and if that difference is between 0 and 1 dB, 3 dB are added to the higher sound source levels; if the difference is between 2 and 3 dB, 2 dB are added to the highest sound source levels; if the difference is between 4 and 9 dB, 1 dB is added to the highest sound source levels; and with differences of 10 or more dB, there is no addition. For two concurrent sources of different type (*i.e.*, impact and vibratory driving), there is no sound source addition. Combinations of concurrent pile driving and the predicted source values are shown in Table 52. All concurrent pile driving would consist of two vibratory hammers.

Table 51. Sound Source Levels for Single Hammer Pile Driving

Pile Type	Source Level (at 10 m)			Proxy	Source
	Peak (dB re 1 μPa)	SEL (dB re 1 μPa2 sec)	RMS (dB re 1 μPa)		
Impact					
Sheet Pile	205	180	190	24-inch (61-cm) AZ Sheet Pile	Caltrans (2015)
24-inch Steel Pipe Pile	203	177	190	24-inch (61-cm) Steel Pipe Pile	Caltrans (2015)
48-inch Steel Pipe Pile	208	180	195	48-inch (121.9-cm) Steel Pipe Pile	Caltrans (2020)
60-inch Steel Pipe Pile	210	185	195	60-inch (152.4 cm) Steel Pipe Pile	Caltrans (2020)
Vibratory					
Sheet Pile	N/A	N/A	160	24-inch (61-cm) AZ Sheet Pile	Caltrans (2015)
24-inch Steel Pipe Pile)	N/A	N/A	163	20- to 24- inch (50.8- to 61-cm) Steel Pipe Pile	U.S. Navy (2012, 2013), (Miner, 2020)
66-inch Steel Pipe Pile	N/A	N/A	170	49- to 72-inch (124.5-182.9-cm) to Steel Pipe Piles (average)	Caltrans (2020), Illingworth & Rodkin (2021)

Table 52. Concurrent Pile Driving Scenarios and Predicted Source Levels (All Vibratory Hammers)

Concurrent Pile Driving Scenarios	Predicted RMS (dB re 1 µPa) at 10 m
66-inch Steel Pipe Pile x 2	173
66-inch Steel Pipe Pile with Sheet Pile	170
Sheet Pile x 2	163
24-inch Steel Pipe Pile with Sheet Pile	165
24-inch Steel Pipe Pile x 2	166

Transmission loss (TL) is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water depth, water chemistry, and bottom composition topography. The general formula for underwater TL is:

$$TL = B * \text{Log}_{10} (R_1 / R_2),$$

where

TL = transmission loss in dB;

B = transmission loss coefficient;

R_1 = the distance of the modeled SPL from the driven pile; and

R_2 = the distance from the driven pile of the initial measurement.

Absent site-specific acoustical monitoring with differing measured transmission loss, a practical spreading value of 15 is used as the transmission loss coefficient in the above formula. Project and site-specific transmission loss data for 8 Star Alaska's project area in Cook Inlet are not available; therefore, the default coefficient of 15 is used to determine the distances to the Level A and Level B harassment thresholds for all pile driving. All Level B harassment isopleths are reported in Table 10. However, 8 Star Alaska has stated that they will conduct SSV for pile driving. Following the analysis of SSV results, 8 Star Alaska may propose revised estimated Level A and Level B harassment zones (for the purpose of monitoring and reporting) and adjusted shutdown zones accordingly for NMFS review and approval.

The ensonified area associated with Level A harassment is more technically challenging to predict due to the need to account for a duration component. Therefore, NMFS developed an optional User Spreadsheet tool to accompany the 2024 Updated Technical Guidance that can be used to relatively simply predict an isopleth distance for use in conjunction with marine mammal density or occurrence to help predict potential takes. We note that because of some of the assumptions included in the methods underlying this optional tool, we anticipate that the resulting isopleth estimates are typically going to be overestimates of some degree, which may result in an overestimate of potential take by Level A harassment. However, this optional tool

offers the best way to estimate isopleth distances when more sophisticated modeling methods are not available or practical. For stationary sources such as impact and vibratory pile driving and AHTs engaged in anchor handling, the optional User Spreadsheet tool predicts the distance at which, if a marine mammal remained at that distance for the duration of the activity, it would be expected to incur AUD INJ. Inputs used in the optional User Spreadsheet tool are provided in Table 53, and the resulting estimated isopleths are reported in Table 54.

Note also and as explained above, NMFS used updated guidance to calculate the zone sizes for Level A and Level B zones for pile driving (89 FR 84872; October 24, 2024). Based on this updated guidance, some zones may differ from the 2020 biological opinion.

Table 53. User Spreadsheet Input Parameters Used for Calculating Level A Harassment Isopleths in Cook Inlet

Pile	Piles Per Day	Strikes Per Pile	Duration to Drive Pile (min)	Weighting Factor Adjustment
Impact				
Sheet Pile	30	1,000	N/A	2
24-inch Steel Pipe Pile	4	1,000	N/A	2
48-inch Steel Pipe Pile	3	1,000	N/A	2
60-inch Steel Pipe Pile	4	1,000	N/A	2
Vibratory				
Sheet Pile	30	N/A	15	2.5
24-inch Steel Pipe Pile	8	N/A	15	2.5
66-inch Steel Pipe Pile	7	N/A	15	2.5
Concurrent Pile Driving with Two Vibratory Hammers				
66-inch Steel Pipe Pile x 2	1	N/A	105*	2.5
66-inch Steel Pipe Pile with Sheet Pile	1	N/A	450*	2.5
Sheet pile x 2	1	N/A	450*	2.5
24-inch Steel Pipe Pile with Sheet Pile	1	N/A	450*	2.5
24-inch Steel Pipe Pile x 2	1	N/A	120*	2.5

*This value represents the maximum duration of concurrent activity.

Table 54. Calculated Distances to Level A and Level B Harassment Isopleths for Pile Driving in Cook Inlet

Pile	Level A Harassment Zone (m)			Level B Harassment Zone (m)
	LF Cetacean	HF Cetacean	Otariids	
Impact				
Sheet Pile	6,061	773	2,007	1,000
24-inch Steel Pipe Pile	998	127	331	1,000
48-inch Steel Pipe Pile	1,306	167	432	2,154
60-inch Steel Pipe Pile	3,408	435	1,120	2,154
Vibratory				
Sheet Pile	30	12	13	4,642
24-inch Steel Pipe Pile	20	8	9	7,356
66-inch Steel Pipe Pile	53	21	23	21,544
Concurrent Pile Driving with Two Vibratory Hammers				
66-inch Steel Pipe Pile x 2	85	33	37	34,146
66-inch Steel Pipe Pile with Sheet Pile	141	54	61	21,544
Sheet Pile x 2	48	19	21	7,356
24-inch Steel Pipe Pile with Sheet Pile	32	12	14	11,659
24-inch Steel Pipe Pile x 2	65	25	28	10,000

Except for Level B harassment areas of ensonification for the single hammer vibratory installation of 66-inch steel pipe pile, the concurrent vibratory installation of two 66-inch piles, and the concurrent vibratory installation of a 66-inch steel pipe pile with a sheet pile, estimated areas of ensonification were calculated for pile driving using the formula of $\frac{1}{2}\pi r^2$, where r is the respective isopleth. For the single hammer vibratory installation of 66-inch steel pipe pile, the concurrent vibratory installation of two 66-inch piles, and the concurrent vibratory installation of a 66-inch steel pipe pile with a sheet pile, the Level B harassment isopleths were truncated by land, and therefore $\frac{1}{2}\pi r^2$ was not representative of the area of ensonification. Therefore, mapping software was used to draw the estimated area of ensonification. Estimated Level A and Level B harassment areas of ensonification are in Table 55.

NMFS used the following formula to estimate the area of ensonification for AHTs engaged in anchor handling, where distance traveled per day is the linear distance that the AHTs would be expected to travel over the course of a day, and r is the radial distance of the Level B harassment isopleth (3.85 km). 8 Star Alaska estimates the pipelay rate to be 2,500 feet/day (0.762 km/day), so 0.762 km was used as the distance traveled per day.

$$\text{Area of ensonification} = (\text{Distance traveled per day} \times 2r) + \pi r^2$$

Table 55. Calculated Level A and B Harassment Areas of Ensonification for Cook Inlet.

Pile	Level A Harassment Areas of Ensonification (km ²)			Level B Harassment Area of Ensonification (km ²)
	LF Cetacean	HF Cetacean	Otariids	
Impact				
Sheet Pile	57.7	0.94	6.33	1.57
24-inch Steel Pipe Pile	1.56	0.03	0.17	1.57
48-inch Steel Pipe Pile	1.97	0.03	0.22	2.9
60-inch Steel Pipe Pile	18.24	0.3	2.0	7.29
Vibratory				
Sheet Pile	0.00	0.00	0.00	33.85
24-inch Steel Pipe Pile	0.00	0.00	0.00	24.89
66-inch Steel Pipe Pile	0.00	0.00	0.00	62.54
66-inch Steel Pipe Pile x 2	0.01	0.00	0.00	1,426.4
66-inch Steel Pipe Pile with Sheet Pile	0.03	0.00	0.01	722.5
Sheet Pile x 2	0.00	0.00	0.00	85
24-inch Steel Pipe Pile With Sheet Pile	0.01	0.00	0.00	157.08
24-inch Steel Pipe Pile x 2	0.00	0.00	0.00	213.5
AHTs				
Anchor Handling	0.00	0.00	0.00	52.4

Level A harassment zones are typically smaller than Level B harassment zones. However, in some cases, the calculated Level A harassment isopleth is greater than the calculated Level B harassment isopleth. Calculation of Level A harassment isopleths include a duration component, which in the case of impact pile driving, is estimated through the total number of daily strikes and the associated pulse duration. For a stationary sound source, we assume here that an animal is exposed to all of the strikes expected within a 24-hour period. Calculation of a Level B harassment zone does not include a duration component. Depending on the duration included in the calculation, the calculated Level A harassment isopleths can be larger than the calculated Level B harassment isopleth for the same activity.

Mainline Installation

8 Star Alaska intends to use AHTs to position a pipelaying barge in order to install the pipe on the seafloor for the Mainline across Cook Inlet. For the nearshore pipelay, planned for Year 3, an AHT would engage in anchor handling to moor a pull barge, and is expected to be used for two days of work, one day on the west coast near Beluga and one day on the east coast near Suneva Lake. For offshore pipelay, AHTs would be engaged in anchor handling to repeatedly position the barge during the duration of pipelay. Consistent with other tug activities, including those for tugs towing a jack-up rig (Furie Operating Alaska, LLC Natural Gas Activities, 89 FR 77836, September 24, 2024; Hilcorp Alaska, LLC, 89 FR 79529, September 30, 2024), NMFS anticipates that the AHTs would operate at approximately 50 percent power during anchor handling activities.

Because of the similarities to tugging activities planned by Hilcorp in Cook Inlet (89 FR 79529, September 30, 2024), NMFS determined it appropriate to adopt the analysis provided for those activities for 8 Star Alaska's planned tugging activities. In addition, we refer here to an existing literature review of available source level data for tugs under load in varying power output scenarios (87 FR 27597, May 9, 2022). Please see that notice for the detailed analysis. While that analysis is for tugs under load towing a jack-up rig, NMFS expects the AHT power output for the proposed anchor handling to be consistent with that assumed for tugs towing a jack-up rig (Furie Operating Alaska, LLC Natural Gas Activities, 89 FR 77836, September 24, 2024; Hilcorp Alaska, LLC, 89 FR 79529, September 30, 2024), and therefore, NMFS determined that this analysis represents the best scientific evidence available for considering the appropriate source level proxy for 8 Star Alaska's proposed AHT use during anchor handling.

In addition to the literature review referenced above, which indicates that a source level of 180 dB for a single AHT would be appropriate, we also consider other relevant information to adequately consider 8 Star Alaska's planned use of three AHTs to handle anchors. If all three tugs were operating simultaneously at 180 dB RMS, the overall source emission levels would be expected to increase by approximately 5 dB when logarithmically adding the sources (*i.e.*, to 185 dB RMS). To further support this level as an appropriate proxy, a sound source verification (SSV) study performed by JASCO Applied Sciences (JASCO) in Cook Inlet in October 2021 (Lawrence et al. 2022) measured the sound source level from three tugs pulling a jack-up rig in Cook Inlet at various power outputs. (Lawrence et al. 2022) reported a source level of 167.3 dB RMS for the 20 percent-power scenario and a source level of 205.9 dB RMS for the 85 percent-power scenario. Assuming a linear scaling of tug power, a source level of 185 dB RMS was calculated as a single point source level for three tugs operating at 50 percent power output.

Therefore, the analyses presented below use a mean tug sound source level scenario of 185 dB RMS to estimate distances to the 120 dB RMS isopleth for three tugs operating at 50 percent power output. In practice, the load condition of the three tugs is unlikely to be identical at all times, so sound emissions would be dominated by the single tug in the group that is working hardest at any point in time. NMFS, therefore, has determined it appropriate to use the source level of 185 dB RMS at 1 m to represent the use of three AHTs. Modeling using this source level resulted in an estimated distance to the 120-dB isopleth of 3,850 m. Please see 89 FR 79529 (September 30, 2024) for full detail.

As explained later, NMFS AKR determined that Level A harassment would not be a reasonably likely outcome of the use of AHTs. In order to characterize the extent of the Level A harassment isopleths to provide additional support for this determination, NMFS AKR used the NMFS user spreadsheet to calculate Level A harassment zones for each hearing group for AHTs conducting anchor handling. NMFS AKR used Tab A (Non-Impulse-Stat-Cont) in the spreadsheet and used a WFA of two, a six hour duration of sound production within a 24 hour period, and a propagation loss coefficient of 18.129. Weston and SLR (Weston Solutions 2022) determined the average 120 dB isopleth was 3,850 meters for a continuous noise source of 185 dB rms SPL across 25 locations in middle Cook Inlet. The coefficient is calculated as $(185 \text{ dB} - 120 \text{ dB})/\text{Log}_{10}(3850/1) = 18.129 \text{ dB per decade.}$)). Estimated Level A and Level B harassment isopleths for AHTs engaged in anchor handling are reported in Table 56.

Table 56. Level A and Level B Harassment Isopleths from AHTs Engaged in Anchor Handling.

Sound Source	Level A Harassment Isopleths (m) ¹			Level B Harassment Isopleth (m) ²
	LF	HF	Otariid	
3 AHTs	53	21	21	3,850
¹ Level A harassment isopleths calculated using NMFS User spreadsheet.				
² Level B harassment isopleth determined using results from Hilcorp's modeling.				

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. In light of the mitigation measures for these activities, which include shutdown zones (see Section 2.1.2), these activities are not anticipated to result in harassment of any listed species, therefore, additional information on these activities is outlined in Section 6.4.1.

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 ensonification for the various Level A and B thresholds by the density (number of marine mammals/unit area).

The thresholds for airborne sound from all construction activities in Cook Inlet are less than 20 m. Since there are no haul-out sites near the location of these construction activities, we do not anticipate that Western DPS Steller sea lions would be exposed to in-air noise from construction activities in Cook Inlet.

Marine Mammal Occurrence in Cook Inlet

8 Star Alaska requested incidental take authorization for humpback whales and beluga whales under the MMPA. In addition to those species, NMFS OPR determined that fin whales and Steller sea lions are likely to occur in the project area during 8 Star Alaska's activities and, accordingly, proposes to authorize take for these species for the Cook Inlet portion of the project.

Densities for marine mammals in Cook Inlet were derived from NMFS Alaska Fisheries Science Center (AFSC)'s Marine Mammal Laboratory (MML) aerial surveys, typically flown in June, from 2000 to 2022 (Rugh et al. 2005; Shelden et al. 2013; Shelden et al. 2015b; Shelden et al. 2017a) except for beluga whales, for which other density data exist, or for Steller sea lions and fin whales, which occur too rarely in the portion of the action area in Cook Inlet to support development of density estimates. Total survey area was not reported for the 2021 or 2022 survey years (Goetz et al. 2023) so total survey area for 2021 and 2022 was estimated as 8,377.2 km² for each year based on previous reports. While the surveys are concentrated for a few days in summer annually, which may skew densities for seasonally present species, they represent the best available long-term dataset of marine mammal sightings available in Cook Inlet. To estimate the average density, the maximum number of individuals per species was divided by the area surveyed, and NMFS used the average across all survey years for each species.

CIBW densities estimated from the AFSC surveys across regions are low; however, there is a known effect of seasonality on their distribution. Thus, densities derived directly from these summer surveys might underestimate the density of CIBWs in lower Cook Inlet at other ice-free times of the year. Therefore, NMFS used the Goetz *et al.* (Goetz et al. 2012) habitat-based model to determine CIBW density. This model is derived from sightings and incorporates depth soundings, coastal substrate type, environmental sensitivity index, anthropogenic disturbance, and anadromous fish streams to predict densities throughout Cook Inlet. The output of this model is a density map of Cook Inlet, which predicts spatially explicit density estimates for CIBW. Using the resulting grid densities, average densities were calculated for three regions applicable to 8 Star Alaska's operations (Table 57). The densities applicable to the area of activity (*i.e.*, the Marine Terminal near Nikiski, the Mainline in middle Cook Inlet, and the Mainline Material Offloading Facility (MOF) near Tyonek) are provided in Table 57 and were carried forward to the exposure estimates as they were deemed to be the most representative estimates available.

Table 57. Calculated Densities.

Species	Density (Animals/km ²)
Humpback whale	0.00185
Beluga whale (Marine Terminal)	0.00016
Beluga whale (Mainline Crossing)	0.01070
Beluga whale (Mainline MOF)	0.03680

Table 58. Marine Mammal Occurrence*.

Species	Expected Occurrence (animals/year)
Fin whale	2
Steller sea lion	9
*Marine mammal occurrence is used when density data is unavailable or not representative of the proposed project area.	

Although data exists for Steller sea lions and fin whales in Cook Inlet from AFSC aerial surveys, this data is based on sightings of Steller sea lions and fin whales that were mostly observed in lower Cook Inlet and is not representative of middle Cook Inlet, where 8 Star Alaska proposes to conduct construction. Therefore, in order to calculate take of these species, NMFS proposes to use marine mammal occurrence.

For Steller sea lions, NMFS proposes to use recent monitoring data from the Port of Alaska (POA) in Anchorage, as these animals would be expected to pass through middle Cook Inlet and therefore be observed in 8 Star Alaska's Project Area. There has been increased monitoring of Steller sea lion presence in Cook Inlet during work at the POA. This increased monitoring indicates that more Steller sea lions are present in Cook Inlet than anticipated in prior analyses, and NMFS believes the results of this recent monitoring are reflective of the likely numbers of Steller sea lions that could be present in the project area of Cook Inlet, which is south of the POA. In 2020-2022 and 2024 (61 North Environmental 2021b; 61 North Environmental 2022a; Easley-Appleyard and Leonard 2022; 61 North Environmental 2025), the maximum number of Steller sea lions observed at POA was nine animals, eight during Petroleum and Cement Terminal (PCT) observations (61 North Environmental, 2022a) and one during NMFS 2021 monitoring effort (Easley-Appleyard and Leonard, 2022). Therefore, NMFS anticipates that up to nine Steller sea lions may occur in the project area per year during the course of 8 Star Alaska's proposed project.

During seismic surveys conducted in 2019 by Hilcorp in the lower Cook Inlet, fin whales were recorded in groups ranging in size from one to 15 individuals (Fairweather, 2020). During the NMFS aerial surveys in Cook Inlet from 2000 to 2018, 10 sightings of 26 estimated individual fin whales in lower Cook Inlet were observed (Shelden *et al.* 2013, 2015, 2016, 2019). Since the

construction activities associated with this project will occur in upper Cook Inlet, NMFS does not expect that a similar level of sightings will occur that far north in the Inlet. Therefore, NMFS anticipates that one group of two fin whales (the lower end of the range of common group sizes) may occur in the project area per year during the course of 8 Star Alaska's proposed project.

Take Estimation

To estimate take by Level B harassment for all species except for fin whale and Steller sea lion, 8 Star Alaska multiplied the area (km²) estimated to be ensonified above the Level B harassment thresholds (Table 55) for each activity by the duration (days) of that activity by the calculated density for each species (number of animals/km²). As described above, take of fin whale and Steller sea lion were calculated using group numbers and estimated frequency of occurrence (see Table 58).

For species where calculated take by Level B harassment was less than the average group size for that species, NMFS rounded up the take estimate to the reasonably likely group size as displayed in Table 59 and described below.

Table 59. Estimated Take by Level B Harassment by Species, Pile Size and Type, and Installation/Removal Method.

Structure	Activity	Days	Fin whale	Humpback whale (all DPSs)	Beluga whale	Steller sea lion
Year 1						
Marine Terminal MOF Combi-Wall	66-inch Steel Pipe Pile x 2 Concurrent (Vibratory)	16	N/A	42.22	3.61	N/A
	66-inch Steel Pipe Pile with Sheet Pile Concurrent (Vibratory)	6	N/A	8.02	0.68	N/A
Marine Terminal MOF Coffe Cell	Sheet Pile x 2 Concurrent (Vibratory)	33	N/A	5.19	0.44	N/A
	24-inch Steel Pipe Pile With Sheet Pile Concurrent (Vibratory)	23	N/A	6.68	0.57	N/A
Total Calculated Year 1		78	N/A	62.11	5.3	N/A
Total Proposed Take by Level B Harassment Year 1	2*	62		11*		9*
Year 2						
Marine Terminal MOF Coffe Cell	Sheet Pile x 2 Concurrent (Vibratory)	32	N/A	5.03	0.43	N/A

Structure	Activity	Days	Fin whale	Humpback whale (all DPSs)	Beluga whale	Steller sea lion
	24-inch Steel Pipe Pile with Sheet Pile Concurrent (Vibratory)	22	N/A	6.39	0.55	N/A
Marine Terminal MOF RoRo Dolphin Quads	48-inch Steel Pipe Pile (Impact)	7	N/A	0.04	0.00	N/A
	24-inch Steel Pipe Pile (Impact)	7	N/A	0.02	0.00	N/A
Mainline MOF	Sheet Pile (Vibratory)	7	N/A	0.44	8.72	N/A
	Sheet Pile (Impact)	7	N/A	0.02	0.40	N/A
Total Calculated Year 2		83	N/A	11.94	10.1	N/A
Total Proposed Take by Level B Harassment Year 2	2*	12		11*		9*
Year 3						
PLF E-W Trestle	60-inch Steel Pipe Pile (Impact)	42	N/A	0.57	0.05	N/A
PLF Berths	48-inch Steel Pipe Pile (Impact)	16	N/A	0.09	0.01	N/A
PLF N-S Trestle	48-inch Steel Pipe Pile (Impact)	16	N/A	0.09	0.01	N/A
Mainline	Anchor handling	2	N/A	0.19	1.12	N/A
Total Calculated Year 3		76	N/A	0.93	1.19	N/A
Total Proposed Take by Level B Harassment Year 3	2*	3*		11*		9*
Year 4						
PLF E-W Trestle	60-inch Steel Pipe Pile (Impact)	14	N/A	0.19	0.02	N/A
PLF Operations Platform	60-inch Steel Pipe Pile (Impact)	6	N/A	0.08	0.01	N/A
PLF Breasting dolphin berths	48-inch Steel Pipe Pile (Impact)	4	N/A	0.02	0.00	N/A
	60-inch Steel Pipe Pile (Impact)	12	N/A	0.16	0.01	N/A
	48-inch Steel Pipe Pile (Impact)	2	N/A	0.01	0.00	N/A

Structure	Activity	Days	Fin whale	Humpback whale (all DPSs)	Beluga whale	Steller sea lion
PLF Mooring dolphin	60-inch Steel Pipe Pile (Impact)	2	N/A	0.03	0.00	N/A
PLF N-S Trestle	48-inch Steel Pipe Pile (Impact)	12	N/A	0.06	0.01	N/A
Mainline	Anchor handling	53	N/A	5.14	29.74	N/A
Total Calculated Year 4		105	N/A	5.70	29.78	N/A
Total Proposed Take by Level B Harassment Year 4	2*	6		30		9*
Year 5						
PLF Mooring dolphin	48-inch Steel Pipe Pile (Impact)	6	N/A	0.03	0.00	N/A
	60-inch Steel Pipe Pile (Impact)	14	N/A	0.19	0.02	N/A
PLF Catwalk	60-inch Steel Pipe Pile (Impact)	16	N/A	0.22	0.02	N/A
Total Calculated Year 5		36	N/A	0.44	0.04	N/A
Total Proposed Take by Level B Harassment Year 5	2*	3*		11*		9*

*Take number adjusted for group size

During annual aerial surveys conducted in Cook Inlet from 2000 to 2016, humpback group sizes ranged from one to 12 individuals, with most groups comprised of one to three individuals (Shelden et al. 2013). Three humpback whales were observed in Cook Inlet during SAEExploration's seismic study in 2015: two near the Forelands and one in Kachemak Bay (Kendall et al. 2015b). In total, 14 sightings of 38 humpback whales (ranging in group size from 1 to 14) were recorded in the 2019 Hilcorp lower Cook Inlet seismic survey in the fall (Fairweather Science 2020). Two sightings totaling three individual humpback whales were recorded near Ladd Landing north of the Forelands on the recent Harvest Alaska CIPL Extension Project (Sitkiewicz et al. 2018a). Based on documented observations from the CIPL Extension Project, which is the data closest to 8 Star Alaska's project area, where the calculated take is less than one whale, NMFS OPR is proposing to authorize three takes by Level B harassment for humpback whales for years 3 and 5. This will account for the potential for humpback whale exposure to Level B harassment, as reflected in the calculated number, and also the likelihood that a humpback whale will not be traveling alone but in a group. For years 1, 2, and 4, the calculated take exceeds the estimated group size and NMFS OPR is authorizing the calculated take numbers in Table 59 in those years.

The 2018 MML aerial survey (Shelden and Wade 2019) estimated a median group size of approximately 11 beluga whales, although group sizes were highly variable (two to 147 whales) as was the case in previous survey years (Boyd et al. 2019). Over three seasons of monitoring at the Port of Alaska, 61 North reported groups of up to 53 belugas, with a median group size of three and a mean group size of 4.4 (61 North Environmental 2022a; 61 North Environmental 2022c; 61 North Environmental 2022b). Additionally, vessel-based surveys in 2019 observed beluga whale groups in the Susitna River Delta that ranged from five to 200 animals (McGuire *et al.*, 2022). The very large groups seen in the Susitna River Delta are not expected in the areas of 8 Star Alaska's construction. However, smaller groups (*i.e.*, around the median group size) could be traveling through to access the Susitna River Delta and other nearby coastal locations, particularly in the shoulder seasons when belugas are more likely to occur in middle Cook Inlet. Therefore, NMFS is proposing to authorize 11 takes by Level B harassment of beluga whale in Years 1-3, and 5, in which calculated exposures were below the median group size. This will account for the potential for Cook Inlet beluga whale exposure to Level B harassment, as reflected in the calculated number, and also the likelihood that Cook Inlet beluga whales will mostly likely be traveling in a group of a size similar to the median group size. Calculated takes of beluga whales was greater than the median group size in year 4 and therefore were not adjusted for group size.

8 Star Alaska proposes to shut down at the Level A harassment isopleth for all vibratory pile driving activities, so we have not calculated Level A harassment by species for vibratory pile driving activities. The Level A shutdown zones for all marine mammal except Cook Inlet beluga whales are included in Table 28. The shutdown zones for Cook Inlet beluga whales (which actually correspond to the more expansive Level B zones) are also included in Table 28, and the Level A harassment isopleths are included in Table 54. As noted in Section 2.1.2, some of the shutdown zones for Cook Inlet beluga whales are larger than PSOs can fully monitor: in those instances, PSOs must order a shutdown whenever a beluga whale is seen within the shutdown zone but at no less than 1000 m (note: all Level A zones for Cook Inlet beluga whales are less than 1000 m). The largest Level A shutdown zone for marine mammals other than beluga whales during vibratory pile driving is 150 m (Table 28), and the largest Level A harassment isopleth for Cook Inlet beluga whales is 54 m. NMFS anticipates that 8 Star Alaska would be able to adequately monitor these zones and shutdown appropriately. NMFS, therefore, does not expect and does not propose to authorize Level A harassment due to vibratory pile driving for any species.

Due to the characteristics of noise produced by AHTs, *e.g.*, low-intensity source levels relative to impact pile driving, and transitory nature of occurrence of marine mammal species in this area, auditory injury is not a likely outcome of this activity. The Level A zones are also relatively small, with the largest Level A harassment zone 53 m (Table 56), and vessels would be relatively slow moving, allowing marine mammals sufficient time to avoid exposure to sound source levels that could rise to Level A take. Therefore, NMFS does not expect, and does not propose to authorize, take by Level A harassment due to AHTs engaging in anchor handling.

To estimate take by Level A harassment from impact pile driving, 8 Star Alaska multiplied the area (km²) estimated to be ensonified above the Level A harassment thresholds (Table 55) for each impact pile driving activity by the duration (days) of that activity by the calculated density for each species (number of animals/km²). Due to the infrequency of occurrence of fin whales

and Steller sea lions in middle Cook Inlet, NMFS does not expect these species to enter Level A harassment zones for sufficient duration to incur injury, and is not proposing to authorize take by Level A harassment of these species.

When attributing take to respective humpback whale stocks for each year, NMFS assumed that 89 percent of calculated take would be from the Hawai'i stock, 10.7 percent would be from the Mexico-North Pacific stock, and 0.3 percent would be from the Western North Pacific stock, as described in Wade (2021) (see Table 61). Although the number calculated in Wade (2021) for the Western North Pacific stock is less than 0.5 animals, NMFS is conservatively attributing one take by Level B harassment to the Western North Pacific stock of the humpback whale.

For species for which take by Level A harassment is anticipated (humpback whales), those estimated takes by Level A harassment were subtracted from the estimated takes by Level B harassment to avoid double-counting the same exposures as both Level A and Level B harassment. Adjustments are reflected in Table 61.

Table 60. Estimated Take by Level A Harassment by Species, Pile Size and Type, and Installation/Removal Method*.

Structure	Activity	Days	Fin whale	Humpback whale	Beluga whale**	Steller sea lion
Year 2						
Marine Terminal MOF RoRo Dolphin Quads	48-inch Steel Pipe Pile (Impact)	7	N/A	0.03	0	N/A
	24-inch Steel Pipe Pile (Impact)	7	N/A	0.02	0	N/A
Mainline MOF	Sheet Pile (Impact)	7	N/A	0.75	0.02	N/A
Total Calculated Year 2		83	N/A	0.79	0	N/A
Total Proposed Take by Level A Harassment Year 2			0	1	0	0
Year 3						
PLF E-W Trestle	60-inch Steel Pipe Pile (Impact)	42	N/A	1.42	0	N/A
PLF Berths	48-inch Steel Pipe Pile (Impact)	16	N/A	0.06	0	N/A
PLF N-S Trestle	48-inch Steel Pipe Pile (Impact)	16	N/A	0.06	0.2	N/A
Total Calculated Year 3		75	N/A	1.53	0	N/A
Total Proposed Take by Level A Harassment Year 3			0	2	0	0

Structure	Activity	Days	Fin whale	Humpback whale	Beluga whale**	Steller sea lion
Year 4						
PLF E-W Trestle	60-inch Steel Pipe Pile (Impact)	14	N/A	0.47	0	N/A
PLF Operations Platform	60-inch Steel Pipe Pile (Impact)	6	N/A	0.20	0	N/A
PLF Breasting dolphin berths	48-inch Steel Pipe Pile (Impact)	4	N/A	0.01	0	N/A
	60-inch Steel Pipe Pile (Impact)	12	N/A	0.41	0	N/A
PLF Mooring dolphin	48-inch Steel Pipe Pile (Impact)	2	N/A	0.01	0	N/A
	60-inch Steel Pipe Pile (Impact)	2	N/A	0.07	0	N/A
PLF N-S Trestle	48-inch Steel Pipe Pile (Impact)	12	N/A	0.04	0	N/A
Total Calculated Year 4		105	N/A	1.21	0	N/A
Total Proposed Take by Level A Harassment Year 4			0	1	0	0
Year 5						
PLF Mooring dolphin	48-inch Steel Pipe Pile (Impact)	6	N/A	0.02	0	N/A
	60-inch Steel Pipe Pile (Impact)	14	N/A	0.47	0	N/A
PLF Catwalk	60-inch Steel Pipe Pile (Impact)	16	N/A	0.54	0	N/A
Total Calculated Year 5		36	N/A	1.03	0	N/A
Total Proposed Takes by Level A Harassment Year 5			0	1	0	0
Total Proposed Takes by Level A Harassment Over 5 Years			0	5	0	0
*Vibratory pile driving not included in Level A harassment take calculations because no Level A harassment is expected from vibratory pile driving due to small sizes of zones (see Table 54) and implementation of shutdown zones to prevent Level A harassment from vibratory pile driving (see Section 2.1.2). **Because the calculated Level A take for beluga whales is so small (0.02 for one activity in Year 2 and 0.20 for one activity in Year 3), Level A take is not proposed. In addition, because of the mitigation measures designed to prevent Level A take, no Level A take is anticipated or authorized for Cook Inlet beluga whales.						

Table 61. Level A Harassment and Level B Harassment Takes of Marine Mammals Proposed for Authorization Incidental to All Activities Over the Course of 8 Star Alaska's 5-Year Project in Cook Inlet

Marine Mammal species	Stock	Year 1		Year 2		Year 3		Year 4		Year 5		Five Year Total	
		Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B
Fin whale	Northeast Pacific	0	2	0	2	0	2	0	2	0	2	0	10
Humpback whale	Hawai'i	0	56	1	11	2	1	1	4	1	2	5	74
	Mexico-North Pacific	0	6	0	1	0	0	0	1	0	0	0	8
	Western North Pacific	0	1	0	0	0	0	0	0	0	0	0	1
Beluga whale	Cook Inlet	0	11	0	11	0	11	0	30	0	11	0	74
Steller sea lion	Western	0	9	0	9	0	9	0	9	0	9	0	45

6.3.1.2 Effects of Pile Driving

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 28 and Figure 29). Bowhead whales have not been observed migrating inside of the barrier islands (Section 4.3.1, Figure 28 through Figure 34); 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 8 Star Alaska 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, ensonified zones would extend 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 (Richardson et al. 1995a; MMS 2002; SLR Consulting 2017). Also, described in the prior paragraph, bowhead whales typically travel much farther offshore (Figure 28 through Figure 34).

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. 1990; Richardson et al. 1995a). 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 1,306 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 1,306 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 (MacIntyre et al. 2013; Jones et al. 2014a; MacIntyre et al. 2015b), satellite tagging data (Boveng and Cameron 2013; Quakenbush et al. 2019b) 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. If bearded seals are exposed to construction activities during the ice-covered season, responses would likely be similar to those of ringed seals described below. 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).

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 (~18 km northwest of Prudhoe Bay). 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 0), 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 high-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 2016e). 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 (Kendall and Cornick 2015; Castellote et al. 2018a). 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. (2018a) 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. With the implementation of the mitigation measures, NMFS expects that the risk of a beluga whale experiencing TTS will be minimized. The mitigation measures impose more expansive shutdown zones for beluga whales that are commensurate with the Level B, instead of Level A, harassment zones. 8 Star Alaska must not start pile driving if a beluga is observed within the shutdown zones; and must shut down pile driving activities if a beluga is observed within, or likely to enter, the shutdown zones. Although some of these zones are larger than PSOs can reliably monitor, the mitigation measures are triggered anytime a beluga is observed present in or about to enter the shutdown zone but in no case less than 1000 m (which is more extensive than the Level A zones). 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). The construction window is based on the ice-free working window, which is from approximately April 1 through October 31. However, pile driving would occur only from September 8 through May 31 during daylight hours and is estimated to occur 6 days per week. Work for pipelaying would occur 24 hours per day, 7 days per week.

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 2.1.2). 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 or within no less than 1000 m. The intention of the mitigation measures is to minimize exposure to sounds greater than 120 dB and to ensure 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; Koski et al. 2009; Funk et al. 2010b; 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 or within no less than 1000 m) and based on recent observations during construction activities at the Port of Alaska (Sec. 4.1.3) 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 and fin whales

Both pile driving and vibratory sheet pile driving are within the hearing range of humpback and fin 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 (Richardson et al. 1986; Ljungblad et al. 1988; McCauley et al. 2000; Miller et al. 2005; Gailey et al. 2007). 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 and fin 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. Fin whales have also been observed in upper Cook Inlet. While humpback and fin whales will be feeding on small, schooling fish like herring and capelin, as well as euphausiids (krill) while in Cook Inlet, the area is not designated as critical habitat, and is not considered an important area for prey species. Therefore, we expect that pile driving activities could disturb some individuals.

Given the detour response noted above to drilling activities, humpback and fin whales may avoid ensonified zones altogether. However, shutdown zones will prevent exposure of humpback and fin whales to sounds that would cause PTS. TTS may occur if a humpback or fin whale enters the Level B harassment zone. If a humpback or fin 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 and fin whales is expected to have a minor behavioral effect on a few, if any individuals.

Steller sea lions

The ability to detect sound and communicate underwater is important for a variety of Steller sea lion life functions, including reproduction and predator avoidance. NMFS categorizes Steller sea lions in the otariid pinniped functional hearing group, with an applied frequency range between 60 Hz and 39 kHz in water (NMFS 2018a).

Of the Steller sea lions that may occur within the Level B harassment zone of pile driving or vibratory sheet pile driving activities, some sea lions are likely to change their behavioral state – sea lions that avoid these sound fields or exhibit vigilance and raise their heads above water are not likely to experience significant disruptions of their normal behavioral patterns because the ensonified area is temporary and pinnipeds seem rather tolerant of low frequency noise. TTS may occur if a Steller sea lion is within the Level B harassment zone. If a Steller sea lion should experience TTS from noise associated with pile 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 (see *Threshold Shift* section). We anticipate 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 the implementation of shut down mitigation measures.

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 3,850-m clearing zone for belugas and a 1,500 m clearing zone for all other marine mammals 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 (Years 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. 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 (see Section 6.3.1.1). Although 8 Star Alaska 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 harassment 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 (Cook Inlet beluga whales, humpback whales, fin whales, and Steller sea lions) 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, 8 Star Alaska has requested authorization for small amounts of Level B harassment of beluga and humpback whales during pipelaying activities that require anchor handling and dynamic positioning (Table 56).

8 Star Alaska 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.

AHTs cannot shut down once they have begun positioning anchors. Prior to anchor handling, 8 Star Alaska would implement a clearance zone of 1,500 m around AHTs for all marine mammals other than CIBWs. The clearance zone for beluga whales would be equal to the Level B harassment isopleth (3,850 m). This distance is likely farther than what PSOs could reliably monitor. If visibility is less than the Level B harassment isopleth, PSOs would be expected to clear the zone around AHTs at the distance visible to PSOs but no less than 1000 m.

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, and to and from those locations, 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 (Laist et al. 2001; George et al. 2017b). George et al. (2017b) 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. 2012a). 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. 2012a).

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 2008b), 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 2017c).

Although 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 2008d). In 2007, a Steller sea lion with two separate wounds consistent with blunt trauma that may have been from a vessel strike was found in Kachemak Bay (NMFS Alaska Regional Office Stranding Database accessed May 2023). A vessel strike of a Steller sea lion is highly unlikely to occur due to their maneuverability, very low numbers in the Cook Inlet portion of the project, and the slow vessel speeds in and around the project area.

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 8 Star Alaska will not have control over LNG carriers during the 30 year 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 2015), Cook Inlet (Eley 2012), and south to Dixon Entrance (Nuka Research and Planning Group 2012)(Table 62 and Table 63). 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 62. 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
Sperm whale	1	2	3	4.5
Humpback whale	93	29	122	183
Beluga whale	1	0	1	1.5

Table 63 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 during the 30-year operations phase equals 21,842 (Table 25).

Table 63. 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	

^a Eley 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:

$$\# \text{ of vessel strikes per species} / \text{number of vessel transits} = \text{vessel strike rate per species}$$

Table 64 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:

$$\text{vessel strike rate} \times 21,842 \text{ vessel transits during AK LNG operations} = \# \text{ of vessel strikes}$$

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 64. 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 Total 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	-
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
^a Rounded 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 Minor Stressors to ESA-Listed Species

Sperm whales are not observed in upper Cook Inlet or in the Prudhoe Bay project areas, therefore it is unlikely that sperm whales will be affected by dredging, trenching, screeding/grading, geohazard and geotechnical surveys, seafloor disturbance and habitat alteration, and aircraft noise. Sperm whales are only expected to be exposed to project stressors due to vessel transit (including vessel noise), authorized and unauthorized discharge, invasive species, 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.

8 Star Alaska 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, 8 Star Alaska will implement the larger clearance zone for anchor handling of 3,850 m for belugas and 1,500 m for all other marine mammals. With proper implementation of these clearance zones and the shutdown zones for dredging and trenching, we conclude that it is extremely unlikely that marine mammals in Cook Inlet (Cook Inlet beluga whales, listed humpback whales, fin whales, and Western DPS Steller sea lions) will be exposed to dredging/trenching sounds capable of harassing them. 8 Star Alaska 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*).

8 Star Alaska 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 listed marine mammals in Prudhoe Bay (bowhead whales and ringed and bearded seals) 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). 8 Star Alaska 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 required 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 in Prudhoe Bay (bowhead whales and ringed and bearded seals) 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 8 Star Alaska 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 listed marine mammals in Cook Inlet (Cook Inlet beluga whales, listed humpback whales, fin whales, and Western DPS Steller sea lions) and in Prudhoe Bay (bowhead whales and ringed and bearded seals) will be exposed to sounds from geotechnical and geohazard surveys capable of harassing them. 8 Star Alaska 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 2.1.1.2 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 these project activities will occur, they are highly unlikely to be affected by either the loss of prey, or the loss of habitat due to fill or by impacts to water quality (turbidity and sedimentation). 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 where these activities will occur. 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 screeding over a limited amount of time and area is not anticipated to have a measurable 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 2.1.1.2) 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 0. 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. 2014b). 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. 8 Star Alaska 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 2020). The limited and transitory impacts to seafloor disturbance and habitat alteration will be minor to Steller sea lions, and sea lion prey. Other species are considered below.

Cook Inlet Beluga Whales, Humpback Whales, and Fin Whales

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).

Humpback whale and fin whale prey includes euphausiids (krill), copepods, juvenile salmonids, herring, Arctic cod, walleye pollock, pteropods, and cephalopods (Johnson and Wolman 1984; Perry et al. 1999; Straley et al. 2018).

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 humpback whales, fin whales, or beluga whales. 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 (Rhoads et al. 1978; Powilleit et al. 2009). While humpback and fin whales will be feeding on small, schooling fish like herring and capelin, as well as euphausiids (krill) while in Cook Inlet, the area is not designated as critical habitat, and is not considered an important area for their prey species. 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, humpback whales, or fin 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 beluga whales 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, beluga whales, humpback whales, and fin whales 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. 8 Star Alaska 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 (Efroymson 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, humpback, and fin 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 for Cook Inlet beluga whales 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, humpback whale, or fin whale approaches the 215 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, humpback whales, or fin whales will be avoided through mitigation.

Area 2 of Cook Inlet Beluga Whale 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 whales and their prey.

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 beluga whales, humpback whales, and fin whales), 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 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, humpback whales, and fin whales.

In summary, 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, construction footprint 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). 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. 1995a). Richardson et al. (1995a) 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. 1995a). 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. 1995a).

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. 1995a).

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 (Richardson et al. 1985; Patenaude et al. 2002a). Richardson et al. (1995a) 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 1993a). 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. (2002a) 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. 2002a). Patenaude et al. (2002a) 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 (Holliday et al. 1983; Cummings et al. 1986; Kelly et al. 1986). Richardson et al. (1995a) 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 (Burns and Harbo 1972; Burns and Frost 1979b; Alliston 1981; 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. (1995a) 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 (Smith and Hammill 1981; Born et al. 1999). 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. 1995a).

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. 1995a). 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. (2002a) 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.

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 Cook Inlet beluga whales is very small, and thus adverse effects to this species are extremely unlikely to occur. If beluga whales are exposed to aircrafts, any impacts would be very minor, and thus the adverse effects to Cook Inlet belugas will be immeasurably small.

Humpback and Fin 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. 2002a), 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. 1995a). 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 (Richardson et al. 1995a; Patenaude et al. 2002a; Weilgart 2007b).

Given the short duration of exposure of aircrafts, the altitude of 1,500 ft helicopters and fixed wing will travel (along with additional mitigation measures; see Section 2.1.2), and the limited numbers of humpback and fin whales present in Cook Inlet, we conclude that the probability of aircraft traffic disturbing humpback or fin whales is very small, and thus adverse effects to this species are extremely unlikely to occur. With the implementation of mitigation measures, we do not expect humpback or fin whales to respond to aircraft if they are exposed. For these reasons, the impact of project aircraft is very minor, and thus the adverse effects to humpback and fin whales will be immeasurably small.

Steller sea lions

Aircraft may also disturb Steller sea lions, especially if hauled out. Disturbance of a rookery or haulout has the potential to result in serious injury or death, predominantly from trampling. Over 1,000 sea lions were observed stampeding off a beach in response to a large helicopter over a mile away (Withrow 1982). However, there are no rookeries or haulouts within Cook Inlet. 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 Steller sea lions is very small, and thus adverse effects to Steller sea lions are extremely unlikely to occur. Additionally, since pinniped reactions have previously been documented as temporary and aircraft exposure would be limited in duration, we conclude that if Steller sea lions are exposed to aircraft the impact is expected to be very minor, and thus adverse effects to these species 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, as well as to and from those locations, 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 in Prudhoe Bay and Cook Inlet and along the proposed transit routes will be temporary and unlikely to rise to the level of take and the effects to listed species (bowhead whales, Cook Inlet beluga whales, humpback whales, fin whales, sperm whales, Steller sea lions, and ringed and bearded seals) 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. 8 Star Alaska has requested authorization of Level B take for anchor handling activities. Noise produced by this specific form of vessel activity is discussed further in Section 6.3.1.2.

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, 8 Star Alaska 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, 8 Star Alaska 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, 8 Star Alaska will ensure that all contractors comply with the Project SPCC Plan and Stormwater Pollution Prevention Plan. 8 Star Alaska 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 8 Star Alaska 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. 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). 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. In addition, extreme tidal mixing will greatly reduce the size of the hypoxic plume. Therefore, the effects of small or large releases of natural gas on listed marine mammals are expected to be only temporary and minor.

In conclusion, it is not likely that listed marine mammals would be exposed to unauthorized discharges and an exposure, if any, would result in minor effects to listed species (bowhead

whales, Cook Inlet beluga whales, humpback whales, fin whales, sperm whales, Steller sea lions, and ringed and bearded seals).

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 (Trombulak et al. 2004; Norse and Crowder 2005). Ballast water, used by many vessels associated with this project, is an important vector for introducing exotic species. Project vessels and 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 8 Star Alaska 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.”

8 Star Alaska 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. 8 Star Alaska 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, 8 Star Alaska 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, 8 Star Alaska 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 8 Star Alaska’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 (bowhead whales, Cook Inlet beluga whales, humpback whales, fin whales, sperm whales, Steller sea lions, and ringed and bearded seals).

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.

8 Star Alaska will comply with Federal regulations regarding trash and debris, and one of the mitigation measures requires that no trash or other debris will be thrown overboard and vessels will not allow tow lines to remain in the water. As a result, 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 and along the marine transit routes (bowhead whales, Cook Inlet beluga whales, humpback whales, fin whales, sperm whales, Steller sea lions, and ringed and bearded seals).

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, trenching, grading, 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 than pile driving, 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, western DPS Stellar sea lions, 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 65.

Table 65. 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 (Hart Crowser Inc. et al. 2009; CalTrans 2010; Ruggerone et al. 2014). The results of these studies showed that behavioral responses 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-seconds waiting period, then two subsequent three-strike sets with associated 30-seconds 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 Toresen 1988; Ona and Godø 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110–130 dB re 1 μ Pa rms (Olsen 1979; Ona and Toresen 1988; Ona and Godø 1990; Nakken 1992). 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 and western DPS Steller sea lions 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.

Some continuing non-Federal activities are reasonably certain to contribute to changing environmental conditions within the action area. However, it is difficult if not impossible to distinguish between the action area’s future environmental conditions caused by global changes in environmental conditions 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).

7.1 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 exploration and development, scientific research, tourism, and commercial shipping activities will continue into the future, in the same general portions of the marine transit route in which

they presently occur. 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.

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. NMFS will do likewise for the salmon fishery NMFS manages in the Cook Inlet EEZ. 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 Plan 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 2008b). 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 listed species 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 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. 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 Cetacean Risk Analysis

8.1.1 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. Screeding/under water grading, and trenching activities will not result in take due to the implemented mitigation measures. Exposure to vessel noise, aircraft noise, seafloor disturbance and habitat alteration, vessel strikes, invasive species, 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 50). 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. No Level A take is anticipated or authorized: Due 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.

Exposure to vessel noise, aircraft noise, effects of seafloor disturbance and habitat-altering activities, invasive species, and pollution may occur as part of the proposed action, but impacts, if any, are considered minor and are not expected to rise to the level of take. Vessel strikes to bowhead whales are 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 outside the barrier islands.

The Western Arctic stock of bowhead whales has been increasing at approximately 3.2-3.7 percent per year (Lowry et al. 2004; Schweder and Sadykova. 2009; Givens et al. 2013), while simultaneously exposed to sustained subsistence harvest, vessel traffic, 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 2017c), 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 (Zeh et al. 2002; Schweder et al. 2010) 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 (Lowry et al. 2004; George et al. 2011; Suydam et al. 2013b).

As mentioned in the *Environmental Baseline* section, bowhead whales may be impacted by a number of anthropogenic activities in Prudhoe Bay. Human activity 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, direct mortalities, and research, in addition to factors operating on a larger scale such as predation, disease, and changing environmental conditions. These species may be affected by multiple threats at any given time, compounding the impacts of the individual threats.

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. Here, the proposed action will not reduce the reproduction, numbers, or distribution of the species. As a result, the AK LNG project, when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not likely to appreciably reduce the bowhead whale's likelihood of surviving or recovering in the wild.

8.1.2 Beluga, Humpback, and Fin Whales

Based on the results of the *Exposure Analysis*, we expect Cook Inlet beluga whales, Western North Pacific DPS and Mexico DPS humpback whales, and fin whales may be adversely affected by exposure to pile driving noise and, for Cook Inlet beluga whales and humpback whales, exposure to anchor handling noise (Table 61). With the implementation of mitigation measures, exposure to vessel and aircraft noise and presence, trenching, sea floor disturbance and habitat alteration, trash and debris, sound from geotechnical and geohazard surveys, and small oil, natural gas, and contaminant spills may occur, but the expected effects to beluga whales, fin 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 and fin 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 and fin whales by bulk LNG carriers during operations (Table 64). Effects on belugas, humpbacks, and fin whales due to invasive species, and marine debris associated with the project are extremely unlikely to occur due to implementation of mitigation measures. Finally, the probability of impacts on prey for these whales 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 11 percent to be from the Mexico DPS and one percent to be from the Western North Pacific DPS (Wade 2021). These proportions are used to estimate exposures of whales within each DPS based on our estimates of exposures of humpbacks overall.

Our estimates of 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 fin, 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. Any underwater leak would boil to the surface and evaporate.

As mentioned in the *Environmental Baseline* section, fin whales, 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 changing environmental conditions. These 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 fin and humpback whale populations because upper Cook Inlet, where most effects from Cook Inlet construction will occur, is utilized only occasionally by these species, and then only in very small numbers. NMFS expects a total of 10 Level B takes for fin whales and no Level A takes associated with construction activities in Cook Inlet (potential exposure to noise from pile driving). NMFS expects a total of 9 Level B takes for Mexico DPS humpback whales and 1 Level B take for Western North Pacific DPS humpback whales associated with construction activities in Cook Inlet (potential exposure to noise from pile driving and anchor handling). No Level A harassment takes are authorized for the Mexico DPS or Western North Pacific DPS under the ESA. Fin and humpback whales are also likely to experience adverse effects in the form of potential vessel strike due to bulk carriers shipping LNG over the life of the project (Table 64). One fin whale, 2 Mexico DPS humpback whales, and no Western North Pacific DPS humpback whales are expected to be taken in this way during the 30-year projected lifetime of

this project. Because the action will not reduce the reproduction, numbers, or distribution of the species, NMFS concludes that the proposed action, when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not expected to appreciably reduce the likelihood of survival or recovery of fin whales, 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 fin or humpback whales may experience Level A and/or Level B acoustic harassment, may experience masking, and may exhibit behavioral responses from project activities. Cook Inlet beluga whales may experience 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). The implementation of shutdown zones will also ensure that Cook Inlet beluga whales are not exposed to Level A harassment. 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.

The trend reported in Sheldon and Wade (2019) indicates the population was initially increasing but then started declining after 2010 until 2018. With the addition of survey data from 2021 and 2022, the trend in the updated time-series suggests the population is stable and may be slightly increasing (Figure 42) (Goetz et al. 2023). The summer range of belugas in Cook Inlet has contracted steadily since the late 1970s (Figure 43). 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 47).

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 (NMFS 2016d; Muto et al. 2018). 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 2019b; 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 by belugas. 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 2016d).

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. The mitigation measures impose more expansive shutdown zones for pile driving activities that are commensurate with the Level B, instead of Level A, harassment zones. 8 Star Alaska must not start pile driving if a beluga is observed within the shutdown zones; and must shut down pile driving activities if a beluga is observed within, or likely to enter, the shutdown zones. Although some of these zones are larger than PSOs can reliably monitor, the mitigation measures are triggered anytime a beluga whale is observed present in or about to enter the shutdown zone but in no case less than 1000 m. This 1000-m zone is more extensive than the Level A harassment zone. Additionally, the mitigation 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 or within 1000 m. 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, 8 Star Alaska will deploy bubble curtains around piles.⁴⁹ 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. Mitigation measures also include a clearance zone before starting anchor handling activities. NMFS expects a total of 74 Level B takes for Cook Inlet beluga whales. No Level A take is authorized or anticipated.

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,

⁴⁹ 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.

numbers, or distribution of the species, NMFS concludes that the proposed action, when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not expected 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, we anticipate only an 11 percent probability that the individuals struck will be from the Mexico DPS and one percent from the Western North Pacific DPS. Therefore, strikes of a few individual humpback whales are not expected to reduce the viability of either the Mexico or Western North Pacific DPSs.

Fin whales are likely to experience adverse effects in the form of potential vessel strike due to bulk carriers shipping LNG over the life of the project (Table 64). However, no more than one individual fin whale is expected to be taken in this way during the 30-year projected lifetime of this project. Given the extremely small number of potential takes of this species over thirty years, we conclude that this action is not likely to reduce the viability of the 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 fin, Cook Inlet beluga, and Mexico DPS or Western North Pacific DPS humpback whale. Here, the proposed action will not reduce the reproduction, numbers, or distribution of these listed species. As a result, the proposed action when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not likely to appreciably reduce the fin, Cook Inlet beluga, Mexico DPS or Western North Pacific DPS humpback whales' likelihood of surviving or recovering in the wild.

8.1.3 Sperm Whales

Sperm whales are only expected to be exposed to project stressors due to vessel transit (including vessel noise), authorized and unauthorized discharge, invasive species, and project trash and debris. Sperm whales are likely to experience adverse effects in the form of potential vessel strike due to bulk carriers shipping LNG over the life of the project (Table 64). No more than one individual sperm 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 this species. Given the extremely small number of potential takes of sperm whales over thirty years (no more than one) we conclude that this action is not likely to reduce the viability of this population.

Exposure to vessel noise and presence, invasive species, trash and debris, and pollution and discharge of petroleum 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 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. Any underwater leak would boil to the surface and evaporate.

As mentioned in the *Environmental Baseline* section, sperm whales may be impacted by a number of anthropogenic activities related to this project. Human activity 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, direct mortalities, and research, in addition to factors operating on a larger scale such as predation, disease, and changing environmental conditions. Sperm whales may be affected by multiple threats at any given time, compounding the impacts of the individual threats.

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 sperm whale. Here, the proposed action will not reduce the reproduction, numbers, or distribution of the species. As a result, the proposed action, when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not likely to appreciably reduce sperm whales' likelihood of surviving or recovering in the wild.

8.2 Pinniped Risk Analysis

8.2.1 Ringed and Bearded Seals

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, take will be extremely unlikely to occur. Exposure to vessel noise, aircraft noise, seafloor disturbance and habitat alteration may occur but the effects are expected to be immeasurably small. Finally, exposure to vessel strike, and marine debris (e.g., entanglement hazards) is extremely unlikely to occur, and exposure to invasive species and to small oil spill discharge would be minor.

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. 2010c). 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 2,041 ringed seals and 438 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 12 instances of Level A exposure to ringed seals and 3 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. In addition, the majority of take is for Level B behavioral harassment. 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.

Exposure to vessel noise, aircraft noise, and effects of seafloor disturbance and habitat-altering activities 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.

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 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.

As mentioned in the *Environmental Baseline* section, ringed and bearded seals may be impacted by a number of anthropogenic activities related to this project. Human activity 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, direct mortalities, and research, in addition to factors operating on a larger scale such as predation, disease, and changing environmental conditions. Ringed and bearded seals may be affected by multiple threats at any given time, compounding the impacts of the individual threats.

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. Here, the proposed action will not reduce the reproduction, numbers, or distribution of the species. As a result, the AK LNG project, when considered in light of the status of the species, the environmental baseline, and cumulative effects, is not likely to appreciably reduce the ringed seals' or bearded seals' likelihood of surviving or recovering in the wild.

8.2.2 Steller Sea Lions

Based on the results of the exposure analysis, we expect Western DPS Steller sea lions 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. Effects to prey species, exposure to vessel noise, dredging and trenching 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). However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of Steller sea lions. As a result, the Steller sea lions' 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 9 per year for a total of 45 Western DPS Steller sea lions will be exposed to noise from vibratory and impact pile driving and removal that result in Level B behavioral harassment.

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, effects related to invasive species, effects of seafloor disturbance and habitat-altering activities, 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 Steller sea lions is extremely unlikely due primarily to these animals’ agility, but also due to: 1) the low density of Steller sea lions, 2) the implementation of mitigation measures designed to reduce take, and 3) the small number of project vessels. The low number of 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 Steller sea lions 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 these animals. Releases of natural gas during operations (including from bulk carriers) are not expected to have any effect upon Steller sea lions 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. Any underwater leak would boil to the surface and evaporate.

Although the construction activities are likely to cause some individual Steller sea lions 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 mentioned in the *Environmental Baseline* section, Steller sea lions may be impacted by a number of anthropogenic activities related to this project. Human activity 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, direct mortalities, and research, in addition to factors operating on a larger scale such as predation, disease, and changing environmental conditions. Steller sea lions may be affected by multiple threats at any given time, compounding the impacts of the individual threats.

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 sea lions 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 Western DPS Steller sea lion. Here, the proposed action will not reduce the reproduction, numbers, or distribution of the species. As a result, the AK LNG, when considered in light of the status of the species, the environmental baseline, and cumulative effects, project is not likely to appreciably reduce the Western DPS Steller sea lions' 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's biological opinion that the proposed action is not likely to jeopardize the continued existence of Western DPS Steller sea lions, 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 whales, North Pacific right whales, Western North Pacific DPS gray whales, sei whales, 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, Arctic ringed seal critical habitat, Beringia DPS bearded seal critical habitat, Western North Pacific DPS and Mexico DPS humpback whale 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 results from, but is not the purpose of, the carrying out of an otherwise lawful activity conducted by the action agency or applicant (50 CFR 402.02). Based on NMFS guidance, the term "harass" under the ESA means 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). 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)(i) and (ii)). 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. Incidental takes could also result from vessel strikes associated with operation of the AK LNG pipeline.

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. Federal regulations promulgated pursuant to section 4(d) of the ESA extend the section 9 prohibitions to the take of Mexico DPS humpback whales (50 CFR 223.213). 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 Incidental Take Statement (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 threatened species that do not have ESA section 4(d) regulations). Absent such authorization, this incidental take statement is inoperative.

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. 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)(4)). If NMFS Permits Division or FERC (1) fails 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) fails 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 harassment (ringed and bearded seals in Prudhoe Bay) and Level B harassment (bowhead whale, ringed and bearded seals in Prudhoe Bay, and Western DPS Steller sea lions, beluga, fin and humpback whales in Cook Inlet) associated with noise from pile driving, and Level B harassment (beluga and humpback whales in Cook Inlet) associated with 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 will have jurisdiction, discretion, 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 because this take has no associated reasonable and prudent measures or terms and conditions that must be complied with by NMFS, FERC, or 8 Star Alaska due to a lack of jurisdiction by these entities. 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 66. 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 Level B harassment under the Incidental Harassment Authorization for Prudhoe Bay of 110 bowhead whales, 2,041 ringed seals, and 438 bearded seals in Prudhoe Bay over a 1-year period. In addition, 12 ringed seals and three bearded seals are expected to experience Level A take in the Beaufort Sea's Prudhoe Bay over a 1-year period.

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: 74 Cook Inlet beluga whales, 45 Western DPS Steller sea lions, 10 fin whales, and 86 humpback whales. Of the humpback whales, 11 percent or 9 animals is predicted from the Mexico DPS and one percent or one animal from the Western North Pacific DPS (Wade 2021) (Wade et al. 2016). Therefore, NMFS AKR is authorizing 9 Level B harassment takes for the Mexico DPS and one Level B harassment take for Western North Pacific DPS under the ESA.

Up to five humpback whales are expected to experience **Level A** take in Cook Inlet over the 5-year period. However, no animals are predicted to be from the Mexico DPS or the Western North Pacific DPS, and NMFS AKR is authorizing no Level A harassment takes for the Mexico DPS or 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 total authorized MMPA takes of all humpbacks as a surrogate to determine whether take for the listed DPSs has occurred. 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 practicable 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 of 5 Level A or 86 Level B take of any humpback whales.

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 66.

Table 66. 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 (pusa) hispida hispida</i>)	12	2,041
Bearded seal, Beringia DPS (<i>Erignathus barbatus nauticus</i>)	3	438
Humpback whale, Mexico DPS ^a (<i>Megaptera novaeangliae</i>)	0	9
Humpback whale, Western North Pacific DPS ^a (<i>Megaptera novaeangliae</i>)	0	1
Cook Inlet beluga whale (<i>Delphinapterus leucas</i>)	0	74
Fin whale (<i>Balaenoptera physalus</i>)	0	10
Steller sea lion (<i>Eumetopias jubatus</i>)	0	45
^a NMFS anticipates that 86 Level B takes and 5 Level A takes of humpback whales may occur. Because it is not possible to identify a humpback whale by DPS in the field, NMFS AKR uses the total authorized MMPA takes of all humpbacks as a surrogate to determine whether take for the listed DPSs has occurred. Of the total take it is expected that 11 percent is from the Mexico DPS and 1 percent is from the Western North Pacific DPS (Wade 2021).		

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.

Although the biological significance of the expected behavioral responses of Cook Inlet beluga whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, fin whales, Western DPS Steller sea lions, bowhead whales, Arctic ringed seals, and Beringia DPS 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, fin whales, Western DPS Steller sea lions, bowhead whales, Arctic ringed seals, and Beringia DPS bearded seals will be by incidental (acoustic) harassment during construction.

10.3 Reasonable and Prudent Measures

“Reasonable and prudent measures” are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). Failure to comply with RPMs (and the terms and conditions that implement them) may invalidate the take exemption and result in unauthorized take.

RPMs are distinct from the mitigation measures that are included in the proposed action (described in Section 2.2). We presume that the mitigation measures will be implemented as described in this opinion. The failure to do so will constitute a change to the action that may require reinitiation of consultation pursuant to 50 CFR 402.16.

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 to monitor the incidental take of fin whales, Cook Inlet beluga whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, Western DPS Steller sea lions, bowhead whales, Arctic ringed seals, and Beringia DPS 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 LNG carrier 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

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. These terms and conditions are in addition to the mitigation measures included in the proposed action, as set forth in Section 2.1.2 of this opinion. 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(i)(4)).

Any taking that is in compliance with these terms and conditions is not prohibited under the ESA (50 CFR 402.12(i)(6)). As such, partial compliance with these terms and conditions may invalidate this take exemption and result in unauthorized, prohibited take under the ESA. If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the action may lapse.

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. 8 Star Alaska through 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 Level A take of belugas is not authorized, 8 Star Alaska through NMFS Permit Division and FERC must ensure that waters within the Level A harassment zone specific to high-frequency cetaceans are fully monitored for each activity while it is occurring (see Table 54, Level A Harassment Zone, HF Cetacean, for zones for pile driving activities in Cook Inlet and Table 56, Level A Harassment Isopleths, HF, for anchor handling activities in Cook Inlet). 8 Star Alaska through NMFS Permit Division and FERC must ensure that any 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 or other factors.
- C. 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 29).
- D. In the event that the proposed action causes unauthorized take of a marine mammal that results in a serious injury⁵⁰ or mortality, 8 Star Alaska shall immediately cease operations⁵¹ 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;

⁵⁰ Serious injury means “any injury that will likely result in mortality” (50 CFR 216.3).

⁵¹ Curtailing of activities should consider human, property, and environmental safety.

- 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); and
- 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 activity must not be resumed, except in protection of human safety as above, until notified by NMFS via letter, email, or telephone.

- E. In the event that an oiled ESA-listed marine mammal is spotted, the permittee (8 Star Alaska) must report the incident within 24 hours to NMFS AKR, Protected Resources Division, the Marine Mammal Stranding Hotline, and to NMFS Permitting Division (Table 29).
- F. In the event that 8 Star Alaska 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 29). 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).
- G. 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 (8 Star) through NMFS Permits and Conservation Division must fully implement all of the mitigation measures presented in section 2.1.2 of this opinion.
- B. The permittee (8 Star) through NMFS Permits and Conservation Division 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 65), 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 65(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 8 Star Alaska to accomplish the following conservation recommendations:

1. Remove marine debris from the shoreline within and adjacent to the project action area or ‘adopt’ nearby shoreline to conduct marine debris cleanup. This will help prevent ESA-listed species in your project area from becoming harmed by this debris either through ingestion or entanglement.
2. If signs do not currently exist, work with NMFS to purchase and post approved (see example for “Loose the Loop” [here](#)) signs with the NMFS logo and your logo in your action area. Ensure any loop is cut and properly disposed of so it will not end up in the environment and around the neck of an endangered Steller sea lion or on the flipper of a threatened humpback. Ensure there are designated waste sites dedicated to contain and remove construction waste and work with NMFS to purchase and post signs to encourage reporting of marine mammal strandings and entanglements.
3. Encourage and facilitate public reporting of stranded and entangled marine mammals (contact the NMFS statewide [Alaska Marine Mammal Stranding Network](#) 24-hour hotline at 1-877-925-7773). For example, send emails to all staff with hotline details, post details on your website, have a member of the stranding network attend one of your staff meetings to provide information. Information on causes of death for ESA-listed animals

helps us better identify threats to their recovery and ways we can mitigate those threats in hopes of delisting the species.

4. Conduct shoreline surveys, within and adjacent to the project action area, to look for stranded marine mammals and work with stranding network partners to collect samples for contaminants, disease, and genetic analyses, and report strandings to the [Alaska Marine Mammal Stranding Network](#). This will help NMFS better understand threats to ESA-listed species in your project area and how we can help recover their populations for eventual delisting.
5. Fund a new or provide support to an existing [NMFS Ocean Guardian School](#) in Alaska. Supporting this program would help ESA-listed species in multiple ways through the protection and conservation of our oceans (e.g., reducing marine debris, watershed restoration and preservation, ocean health, reducing carbon footprint, etc.).
6. Participate in or support an existing [citizen science program](#). Examples in Alaska that NMFS supports include the [Alaska Beluga Monitoring Program](#), [The Kenai Watershed Forum](#), [Whale Alert](#) and [The Coastal Observation and Seabird Survey Team](#). Citizen science allows for the cost-effective collection of large datasets for ESA-listed species that NOAA Fisheries may not be able to collect without community help. This may provide information that will aid in ESA species recovery or may provide more efficient mitigation measures. For example, data collected by the public for the Alaska Beluga Monitoring Program has provided temporal and spatial information on endangered Cook Inlet belugas that has enabled NOAA Fisheries to refine mitigation measures for development activities in Cook Inlet for the betterment of the species and the project.
7. Provide a sign on the project site that describes the work being carried out and how the applicant/action agency is working with NOAA Fisheries to prevent impacts to ESA-listed species. Include relevant NMFS QR codes on the sign so the public can learn more about marine mammals and the threats they face.

In order to keep NMFS AKR 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)(5)).

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

- 61 North Environmental. 2021a. 2020 Petroleum and Cement Terminal Construction Marine Mammal Monitoring Final Report. Report prepared by 61 North Environmental for Pacific Pile and Marine and the Port of Alaska, Anchorage, AK, April 2021, 197 p.
- 61 North Environmental. 2021b. Port of Alaska Modernization Program Petroleum and Cement Terminal- 2021 Construction, Monthly Marine Mammal Monitoring Report for 31 May to 27 June 2021. Report prepared by 61 North Environmental for Pacific Pile and Marine, Port of Alaska, and National Marine Fisheries Service, Anchorage, AK, July 10, 2021, 181 p.
- 61 North Environmental. 2022a. 2021 Petroleum and Cement Terminal Construction Marine Mammal Monitoring Final Report. Report prepared by 61 North Environmental for Pacific Pile and Marine and the Port of Alaska, Anchorage, AK, March 2022, 173 p.
- 61 North Environmental. 2022b. 2022 Port of Alaska PCT/SFD dredging marine mammal monitoring. Report prepared by 61 North Environmental for Pacific Pile and Marine and the Port of Alaska, Anchorage, Alaska, October 2022, 146 p.
- 61 North Environmental. 2022c. 2022 Port of Alaska South Floating Dock construction marine mammal monitoring. Report prepared by 61 North Environmental for Pacific Pile and Marine and the Port of Alaska, Anchorage, AK, October 2022, 90 p.
- 61 North Environmental. 2025. 2024 Don Young Port of Alaska North Extension Stabilization Phase 1 Protected Species Monitoring, Final report prepared by 61 North Environmental for Manson Construction Inc., Seattle, WA, and The Don Young Port of Alaska Anchorage, Alaska, Anchorage, AK, February 2025.
- Abookire, A. A., and J. F. Piatt. 2005. Oceanographic conditions structure forage fishes into lipid-rich and lipid-poor communities in lower Cook Inlet, Alaska, USA. *Marine Ecology Progress Series* 287:229-240.
- 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., Final report prepared by ABR, Inc., for R & M Consultants, Inc. and the Port of Anchorage, Fairbanks, AK, December 2017, 37 p.
- Adams, J. D., and G. K. Silber. 2017. 2015 vessel activity in the Arctic. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, July 2017. NOAA Technical Memorandum NMFS-OPR-57, 171 p.
- 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, January 2015, 8.

- Aerts, L., M. Blees, 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.
- AGDC. 2020. 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, February 17, 2020, 124 p.
- AGDC. 2024. Application for Incidental Harassment Authorization for Construction of the Alaska LNG Project in Prudhoe Bay, Alaska, June 20, 2024.
- AGDC. 2025. Petition for Incidental Take Regulations for Construction of the Alaska LNG Project in Cook Inlet, Alaska, April 4, 2025.
- Alaska Department of Natural Resources. 2014. Division of Oil and Gas: 2014 Annual Report, Juneau, AK.
- 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, 13.
- 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, D. M., E. Fachon, R. S. Pickart, P. Lin, A. D. Fischer, M. L. Richlen, V. Uva, M. L. Brosnahan, L. McRaven, and F. Bahr. 2021. Evidence for massive and recurrent toxic blooms of *Alexandrium catenella* in the Alaskan Arctic. *Proceedings of the National Academy of Sciences* 118(41).
- Archer, F. I., S. Rankin, K. M. Stafford, M. Castellote, and J. Delarue. 2020. Quantifying spatial and temporal variation of North Pacific fin whale (*Balaenoptera physalus*) acoustic behavior. *Marine Mammal Science* 36(1):224-245.
- 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. Technical report by JASCO Applied Sciences for AECOM and NMFS Alaska Region, JASCO Document #01003, Anchorage, AK, 90 p.
- 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., Anchorage, AK.
- 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.
- 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, 62.
- Baker, C. S. 1985. The population structure and social organization of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. PhD dissertation. University of Hawaii, Honolulu, HI.
- Barbeaux, S. J., K. Holsman, and S. Zador. 2020. Marine heatwave stress test of ecosystem-based fisheries management in the Gulf of Alaska Pacific cod fishery. *Frontiers in Marine Science* 7:703.
- 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.
- Barnett, H. K., T. P. Quinn, M. Bhuthimethee, and J. R. Winton. 2020. Increased prespawning mortality threatens an integrated natural-and hatchery-origin sockeye salmon population in the Lake Washington Basin. *Fisheries Research* 227:105527.
- Barrett-Lennard, L. G., K. Heise, E. Saulitis, G. Ellis, and C. Matkin. 1995. The Impact of Killer Whale Predation on Steller Sea Lion Populations in British Columbia and Alaska. University of British Columbia, 71 p.
- Bates, N. R., J. T. Mathis, and L. W. Cooper. 2009. Ocean acidification and biologically induced seasonality of carbonate mineral saturation states in the western Arctic Ocean. *Journal of Geophysical Research* 114(C11007).

- 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.
- 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. U.S. Dept. Commer., NOAA, NMFS, SWFSC, March 2015. NOAA Technical Memorandum NMFS-SWFSC-540, 263 p.
- 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. 2003a. Acoustic Measurements in Cook Inlet, Alaska During August 2001. August 12, 2002. Revised June 14, 2003.
- Blackwell, S. B., and C. R. Greene, Jr. 2003b. Acoustic measurements in Cook Inlet, Alaska during August 2001. Greenridge Sciences, Inc., Report 271-2 prepared for National Marine Fisheries Service under contract number 40HANF100123, Aptos and Santa Barbara, CA, August 12, 2002. Revised June 14, 2003.
- 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., 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.
- BLM. 2019. Biological Evaluation for the Implementation of the Oil and Gas Lease Sales for the Arctic Wildlife Refuge Coastal Plain. Submitted to NMFS Alaska Region, Anchorage, AK, May 10, 2019.
- BLM. 2020. Appendices B-D to the National Petroleum Reserve in Alaska Final IAP/EIS: Reasonably Foreseeable Development Scenario for the National Petroleum Reserve in Alaska Integrated Activity Plan Environmental Impact Statement. U.S. Dept. of the Interior, Bureau of Land Management, Anchorage, AK, June 2020.
- BLM. 2025. Biological Assessment for the National Petroleum Reserve-Alaska Integrated Activity Plan. U.S. Dept. of the Interior, Bureau of Land Management, Anchorage, AK, June 2025.
- 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. 2011a. 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. 2011b. Biological evaluation for oil and gas activities on the Beaufort and Chukchi sea planning areas, September 2011. OCS EIS/EA BOEMRE 2011.
- BOEM. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017. Final Programmatic Environmental Impact Statement, OCS EIS/EA BOEM 2012-030. USDO, BOEM, Headquarters, Herndon, VA, 2,057.
- BOEM. 2016a. Cook Inlet Planning Area, Oil and Gas Lease Sale 244. Final Environmental Impact Statement. OCS EIS/EA BOEM 2016 069.
- 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. 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. Prepared by U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska OCS Region and submitted to National Marine Fisheries Service and U.S. Fish and Wildlife Service, Anchorage, AK, December 2017, 235 p.
- BOEM. 2017c. Liberty Development and Production Plan Biological Assessment, Anchorage, AK, 235 p.
- BOEM. 2017d. Liberty Development Project Draft Environmental Impact Statement, BOEM 2016-010, Anchorage, AK, 784 p. BOEM 2016-010.

- 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., 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, 117.
- Boveng, P. L., V. I. Chernook, E. E. Moreland, P. B. Conn, I. S. Trukhanova, M. F. Cameron, C. L. Christman, J. A. Crawford, D. M. Glazov, L. Harwood, B. X. Hou, S. M. Koslovsky, J. M. Lindsay, D. I. Litovka, J. M. London, B. T. McClintock, N. Platonov, L. Quakenbush, E. L. Richmond, A. Vasiliev, A. L. V. Duyke, and A. Willoughby. 2025. Abundance and distribution of ringed and bearded seals in the Chukchi Sea: a reference for future trends. *Arctic Science* 11:1-21.
- 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. W. Sheldon, 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., J. J. Burns, G. A. Fedoseev, and B. D. Krogman. 1984. Habitat partitioning by ice-associated pinnipeds: Distribution and density of seals and walruses in the Bering Sea, April 1976. Pages 25-47 in F. H. Fay, and G. A. Fedoseev, editors. *Soviet-American Cooperative Research on Marine Mammals. Volume 1 - Pinnipeds*, NOAA Technical Report NMFS 12. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D. C.
- 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.
- Brandon, J. R., T. Thomas, and M. Bourdon. 2011. Beaufort Sea aerial survey program results. Pages 6-1–6-38 in C. M. Reiser, D. W. Funk, R. Rodrigues, and D. Hannay, editors. *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*, LGL Report P1171E-1. LGL Alaska Research Associates, Anchorage, and JASCO Applied Sciences, Victoria, British Columbia.
- 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, 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.
- Brett, J. R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). *American Zoologist* 11(1):99-113.
- Brewer, A. M., M. Castellote, A. M. Van Cise, T. Gage, and A. M. Berdahl. 2023. Communication in Cook Inlet beluga whales: Describing the vocal repertoire and masking of calls by commercial ship noise. *The Journal of the Acoustical Society of America* 154(5):3487-3505.
- 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.
- Broadwater, M. H., F. M. Van Dolah, and S. E. Fire. 2018. Vulnerabilities of marine mammals to harmful algal blooms. Pages 191-222 *in* S. E. Shumway, J. M. Burkholder, and S. L. Morton, editors. *Harmful Algal Blooms: A Compendium Desk Reference*. John Wiley and Sons, Hoboken, NJ.
- Brodie, P. F. 1993. Noise generated by the jaw actions of feeding fin whales. *Canadian Journal of Zoology* 71(12):2546-2550.
- Brower, A., M. Ferguson, J. Clarke, E. Fujioka, and S. DeLand. 2022a. Biologically Important Areas II for cetaceans within US and adjacent waters—Aleutian Islands and Bering Sea Region. *Frontiers in Marine Science* 9:1055398.
- Brower, A., A. Willoughby, and M. Ferguson. 2022b. Distribution and relative abundance of bowhead whales and other marine mammals in the western Beaufort Sea, 2020. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-AFSC-439.
- Brower, A. A., J. T. Clarke, and M. C. Ferguson. 2018. Increased sightings of subArctic cetaceans in the eastern Chukchi Sea, 2008–2016: population recovery, response to climate change, or increased survey effort? *Polar Biology* 41(5):1033-1039.
- Brower, A. A., A. L. Willoughby, K. A. Scheimreif, and M. C. Ferguson. 2022c. Distribution and relative abundance of bowhead whales and other marine mammals in the western Beaufort Sea, 2021. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-AFSC-455.
- Brower, A. A., N. C. Young, J. C. Freed, B. J. Delean, M. M. Muto, M. J. Keogh, K. L. Raum-Suryan, K. M. Savage, S. S. Teerlink, S. K. Wright, L. A. Jemison, K. M. Wilkinson, J. E. Jannot, and K. A. Somers. 2024a. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2018-2022. U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, October 2024. NOAA Technical Memorandum NMFS-AFSC-2024-11, 7 p + Supporting file.
- Brower, A. A., N. C. Young, J. C. Freed, B. J. Delean, M. M. Muto, M. J. Keogh, K. L. Raum-Suryan, K. M. Savage, S. S. Teerlink, S. K. Wright, L. A. Jemison, K. M. Wilkinson, J. E. Jannot, and K. A. Somers. 2024b. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2018-2022. National Oceanic and Atmospheric

- Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, AFSC Processed Report 2024-11, Seattle, Washington.
- Brown, J., P. Boehm, L. Cook, J. Trefry, W. Smith, and G. Durell. 2010a. cANIMIDA Task 2: Hydrocarbon and metal characterization of sediments in the cANIMIDA study area, Anchorage, Alaska, 241.
- Brown, J., P. Boehm, L. Cook, J. Trefry, W. Smith, and G. Durell. 2010b. cANIMIDA Task 2: Hydrocarbon and metal characterization of sediments in the cANIMIDA study area. Final report to U.S. Dept. of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. Contract No. M04PC00001, OCS Study MMS 2010-004, 241 p.
- Bryant, M. 2009. Global climate change and potential effects on Pacific salmonids in freshwater ecosystems of southeast Alaska. *Climatic Change* 95(1):169-193.
- 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.
- Burkanov, V. N., and T. R. Loughlin. 2005. Distribution and abundance of Steller sea lions, *Eumetopias jubatus*, on the Asian coast, 1720's-2005. *Marine Fisheries Review* 67(2):1-62.
- 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. 1981. Bearded seal *Erignathus barbatus* Erxleben, 1777. Pages 145-170 in S. H. Ridgway, and R. J. Harrison, editors. *Handbook of marine mammals, 2: seals*. Academic Press, New York.
- 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, 1-Marine Mammals*, U.S. Department of Commerce, NOAA, Boulder, CO.
- Burns, J. J., and K. J. Frost. 1979a. The natural history and ecology of the bearded seal, *Erignathus barbatus*. Pages 311-392 in *Environmental assessment of the Alaskan continental shelf, final reports of principal investigators, 19 (1983)*. National Oceanic and Atmospheric Administration, National Ocean Service, Office of Oceanography and Marine Assessment, Ocean Assessments Division, Alaska Office, Juneau.
- Burns, J. J., and K. J. Frost. 1979b. 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.
- Calkins, D. G. 1998. Prey of Steller sea lions in the Bering Sea. *Biosphere conservation: for nature, wildlife, and humans* 1(1):33-44.
- Calkins, D. G., and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. Alaska Dept. of Fish and Game, Anchorage, AK, August 1988, 76 p.
- Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Pages 447-546 *in* Environmental assessment of the Alaska continental shelf. Prepared by the Alaska Department of Fish and Game for the Outer Continental Shelf Environmental Assessment Program, Final Report: Research Unit 243, ACE 8094521, Anchorage, AK.
- 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.
- CalTrans. 2020. Technical guidance for the assessment of hydroacoustic effects of pile driving on fish: Appendix I – Compendium of pile driving sound data. Division of Environmental Analysis, California Department of Transportation, Report Number: CTHWANP-RT-20-365.01.04, Sacramento, CA, October 2020.
- 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. 2010a. Status review of the bearded seal (*Erignathus barbatus*). U.S. Department of Commerce, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, December 2010. NOAA Tech. Memo. NMFS-AFSC-211, 246 p.
- 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. 2010b. Status review of the bearded seal (*Erignathus barbatus*). Seattle, WA. .
- Carder, D. A., and S. H. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale, *Physeter spp.* *The Journal of the Acoustical Society of America* 88(S4 (1990)).
- 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.

- Carretta, J. V., E. M. Oleson, K. A. Forney, A. L. Bradford, K. Yano, D. W. Weller, A. R. Lang, J. Baker, A. J. Orr, B. Hanson, J. E. Moore, M. Wallen, and R. L. Brownell Jr. 2024. U.S. Pacific marine mammal stock assessments: 2023. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-SWFSC-704, 414 p.
- 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., V. A. Gill, C. Garner, A. Gilstad, B. Hou, A. Brewer, and J. Knoth. 2023. Using passive acoustics to identify a winter foraging refugia and quiet space for an endangered beluga population in Alaska. US Department of the Interior, Bureau of Ocean Energy Management, Anchorage, AK, December 2023. OCS Study BOEM 2024-002. Contract No.: M20PG00005.
- Castellote, M., A. Mooney, R. Andrews, S. Deruiter, W.-J. Lee, M. Ferguson, and P. Wade. 2021. Beluga whale (*Delphinapterus leucas*) acoustic foraging behavior and applications for long term monitoring. PLoS One 16(11):e0260485.
- 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, M. Lammers, J. Jenniges, J. Mondragon, C. D. Garner, S. Atkinson, J. Delevaux, R. Graham, and D. Westerholt. 2020. Seasonal distribution and foraging occurrence of Cook Inlet beluga whales based on passive acoustic monitoring. Endangered Species Research 41:225-243.
- 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. 2018a. Anthropogenic Noise and the Endangered Cook Inlet Beluga Whale, *Delphinapterus leucas*: Acoustic Considerations for Management. Marine Fisheries Review 80(3):36-88.
- Castellote, M., B. Thayre, M. Mahoney, J. Mondragon, M. O. Lammers, and R. J. Small. 2018b. Anthropogenic noise and the endangered Cook Inlet beluga whale, *Delphinapterus leucas*: acoustic considerations for management. Marine Fisheries Review 80(3):63-88.
- Cate, J. R., M. Blees, 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.
- Cavole, L. M., A. M. Demko, R. E. Diner, A. Giddings, I. Koester, C. M. Pagniello, M.-L. Paulsen, A. Ramirez-Valdez, S. M. Schwenck, and N. K. Yen. 2016. Biological impacts of the 2013–2015 warm-water anomaly in the Northeast Pacific: winners, losers, and the future. Oceanography 29(2):273-285.
- 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., G. A. Breed, S. R. Okonnen, M. L. Druckenmiller, L. Quakenbush, J. C. George, B. Adams, W. Maslowski, R. Osinski, and J. Olnes. 2023. Shifts in bowhead whale distribution, behavior, and condition following rapid sea ice change in the Bering sea. *Continental Shelf Research*:104959.
- Citta, J. J., L. Quakenbush, and C. George. 2020. Distribution and behavior of Bering-Chukchi-Beaufort bowhead whales as inferred by telemetry. Pages 31-56 *in* J. C. George, and J. G. M. H. Thewissen, editors. *The Bowhead Whale: Balaena mysticetus: biology and human Interactions*. Elsevier Science & Technology, San Diego, CA.
- 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*.
- Clapham, P. J., A. S. Kennedy, B. K. Rone, A. N. Zerbini, J. L. Crance, and C. L. Berchok. 2012. North Pacific right whales in the southeastern Bering Sea: Final report. Alaska Fisheries Science Center, National Marine Mammal Laboratory, OCS Study BOEM 2012-074, July 2012, Seattle, Washington.
- 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.
- Clarke, J., A. Brower, M. Ferguson, A. Willoughby, and A. Rotrock. 2020. Distribution and relative abundance of marine mammals in the eastern Chukchi Sea, eastern and western Beaufort Sea, and Amundsen Gulf, 2019 annual report. U.S. Dept. of Interior, Bureau of Ocean Energy Management (BOEM), Alaska OCS Region, Anchorage, AK, June 2020. OCS Study BOEM 2020-027 prepared under Interagency Agreement M17PG00031 by the NOAA, Alaska Fisheries Science Center, Marine Mammal Laboratory.
- Clarke, J., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013a. Subarctic cetaceans in the southern Chukchi Sea: Evidence of recovery or response to a changing ecosystem. *Oceanography* 26(4):136-149.

- 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. , Seattle, WA.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, A. S. Kennedy, and A. L. Willoughby. 2015. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2014, Seattle, WA.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2017a. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2015. NOAA, NMFS, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA. Annual Report, OCS Study BOEM 2017-019.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2017b. Distribution and relative abundance of marine mammals in the Eastern Chukchi and Western Beaufort Seas, 2016 Annual Report, OCS Study BOEM 2017-078, Seattle, WA.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2018. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2017. NOAA, NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA. Annual Report, OCS Study BOEM 2018-023.
- Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2019. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2018. NOAA, NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory, 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. Report prepared by U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, National Marine Mammal Laboratory for the U.S. Dept. of Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Alaska OCS Region, Anchorage, AK, March 2012. OCS Study BOEMRE 2012-009, 358 p.
- Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2013b. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2012. Report prepared by U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, National Marine Mammal Laboratory for the U.S. Dept. of Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Alaska OCS Region, Seattle, WA. OCS Study BOEM 2013-00117.
- Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2013c. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2012. U.S. Department of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, National Marine Mammal Laboratory, OCS Study BOEM 2013-00117, Seattle, Washington.
- Clarke, J. T., M. C. Ferguson, A. A. Brower, E. Fujioka, and S. Deland. 2023. Biologically important areas II for cetaceans in US and adjacent waters-Arctic region. *Frontiers in Marine Science* 10:156.

- 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.
- Conn, Paul B., Jay M. Ver Hoef, Brett T. McClintock, Erin E. Moreland, Josh M. London, Michael F. Cameron, Shawn P. Dahle, and Peter L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods in Ecology and Evolution 5(12):1280-1293.
- ConocoPhillips. 2023. Fact sheet - May 2023, Alaska.
<https://static.conocophillips.com/files/resources/23-0060-2023-alaska-fact-sheet.pdf>. August 2025.
- 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.
- Crance, J. L., C. L. Berchok, J. Bonnel, and A. M. Thode. 2015. Northeasternmost record of a North Pacific fin whale (*Balaenoptera physalus*) in the Alaskan Chukchi Sea. Polar Biology 38(10):1767-1773.
- 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., 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.

- Crawford, J. A., L. T. Quakenbush, and J. J. Citta. 2015. A comparison of ringed and bearded seal diet, condition and productivity between historical (1975–1984) and recent (2003–2012) periods in the Alaskan Bering and Chukchi seas. *Progress in Oceanography* 136:133-150.
- 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.
- 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, 95-230.
- 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.
- 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.
- Dauginis, A. A., and L. C. Brown. 2021. Recent changes in pan-Arctic sea ice, lake ice, and snow-on/off timing. *Cryosphere* 15(10):4781-4805.
- Deecke, V. B., P. J. Slater, and J. K. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. *Nature* 420(6912):171.
- DeGrandpre, M., W. Evans, M.-L. Timmermans, R. Krishfield, B. Williams, and M. Steele. 2020. Changes in the Arctic Ocean carbon cycle with diminishing ice cover. *Geophysical Research Letters* 47(12):e2020GL088051.
- Dehn, L.-A., G. G. Sheffield, E. H. Follmann, L. K. Duffy, D. L. Thomas, and T. M. O'Hara. 2007. Feeding ecology of phocid seals and some walrus in the Alaskan and Canadian Arctic as determined by stomach contents and stable isotope analysis. *Polar Biology* 30(2):167-181.
- 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.
- Delarue, J., B. Martin, D. Hannay, and C. L. Berchok. 2013. Acoustic occurrence and affiliation of fin whales detected in the Northeastern Chukchi Sea, July to October 2007-10. *Arctic* 66(2):159-172.
- Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks 2013-2017. U. S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Seattle, WA. NOAA Tech. Memo. NMFS-AFSC-401, 86 p.
- 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.
- Druckenmiller, M. L., J. J. Citta, M. C. Ferguson, J. T. Clarke, J. C. George, and L. Quakenbush. 2018. Trends in sea-ice cover within bowhead whale habitats in the Pacific Arctic. *Deep-Sea Research Part II-Topical Studies in Oceanography* 152:95-107.
- 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.
- Easley-Appleyard, B., and K. E. Leonard. 2022. NMFS Port of Alaska visual monitoring project report. U.S. Dept. of Commerce, NOAA, NMFS, Alaska Region, Protected Resources Division, Anchorage, AK, December 2022, 42 p.
- 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.
- Eisner, L. B., Y. I. Zuenko, E. O. Basyuk, L. L. Britt, J. T. Duffy-Anderson, S. Kotwicki, C. Ladd, and W. Cheng. 2020. Environmental impacts on walleye pollock (*Gadus chalcogrammus*) distribution across the Bering Sea shelf. *Deep Sea Research Part II: Topical Studies in Oceanography* 181-182:104881.
- 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.
- Engelhardt, F. R. 1987. Assessment of the vulnerability of marine mammals to oil pollution. Pages 101-115 in J. Kuiper, and W. van den Brink, editors. Fate and effects of oil in marine ecosystems: Proceedings of the Conference on Oil Pollution organized under the auspices of the International Association on Water Pollution Research and Control (IAWPRC) by the Netherlands Organization for Applied Scientific Research TNO Amsterdam, The Netherlands, 23-27 February 1987.
- 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.
http://www.epa.gov/region10/pdf/permits/npdes/ak/cook_inlet_gp/permit_final_akg285100.pdf.
- 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. U.S. Dept. of Commerce and U.S. Environmental Protection Agency, Interagency energy/environment R&D Program Report No. EPA 600/7-80-139 prepared by the NOAA NMFS National Marine Mammal Laboratory for the Marine Ecosystems Analysis Puget Sound Project, Washington, D.C., February 1980.
- 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.
- Fairweather Science, L. 2020. 2019 Hilcorp Alaska lower Cook Inlet seismic survey marine mammal monitoring and mitigation report, Prepared for Hilcorp Alaska, LLC., submitted to National Oceanic and Atmospheric Administration, National Marine Fisheries Service and United States Fish and Wildlife Service, Anchorage, AK, January 2020.
- 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.

- Fearnbach, H., J. W. Durban, S. A. Mizroch, S. Barbeaux, and P. R. Wade. 2012. Winter observations of a group of female and immature sperm whales in the high-latitude waters near the Aleutian Islands, Alaska. *Marine Biodiversity Records* 5:e13.
- Federal Aviation Administration. 2016. Alaskan Region Aviation Fact Sheet.
- Fedewa, E. J., T. M. Jackson, J. I. Richar, J. L. Gardner, and M. A. Litzow. 2020. Recent shifts in northern Bering Sea snow crab (*Chionoecetes opilio*) size structure and the potential role of climate-mediated range contraction. *Deep Sea Research Part II: Topical Studies in Oceanography*:104878.
- 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, Russia.
- Fedoseev, G. A. 2000. Population biology of ice-associated forms of seals and their role in the northern Pacific ecosystems. Center for Russian Environmental Policy, Russian Marine Mammal Council, Moscow, Russia.
- 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.
- FERC. 2019. Alaska LNG Project: Draft Environmental Impact Statement, FERC/EIS-0296D, Washington, D.C., June 2019.
- FERC. 2020. Final EIS for the Alaska LNG Project (CP17-178-000).
- Ferdinando, P. M. 2019. Assessment of heavy metals in subsistence-harvested Alaskan marine mammal body tissues and vibrissae. Master's thesis. Nova Southeastern University, Fort Lauderdale, FL, 144 p.
- 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., D. L. Miller, J. T. Clarke, A. L. Brower, A. Willoughby, and A. Rotrock. 2022. Spatial modeling, parameter uncertainty, and precision of density estimates from line-transect surveys: a case study with Western Arctic bowhead whales. IWC.
- Fey, S. B., A. M. Siepielski, S. Nusslé, K. Cervantes-Yoshida, J. L. Hwan, E. R. Huber, M. J. Fey, A. Catenazzi, and S. M. Carlson. 2015. Recent shifts in the occurrence, cause, and magnitude of animal mass mortality events. *Proceedings of the National Academy of Sciences* 112(4):1083-1088.
- 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 wateregun. Journal of the Acoustical Society of America 111(6):2929-2940.
- 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., and R. L. Brownell Jr. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Paper SC/48/011, La Jolla, California, presented to the IWC Scientific Committee, June 1996 (unpublished).
- 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.
- Fournet, M. E., A. Szabo, and D. K. Mellinger. 2015. Repertoire and classification of non-song calls in Southeast Alaskan humpback whales (*Megaptera novaeangliae*). Journal of the Acoustical Society of America 137(1):1-10.
- 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.
- Freed, J., N. Young, A. Brower, B. Delean, M. Muto, K. Raum-Suryan, K. Savage, S. Teerlink, L. Jemison, and K. Wilkinson. 2023. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2017-2021. U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA, October 2023. AFSC Processed Report 2023-05, 6 p.
- Freed, J. C., N. C. Young, B. J. Delean, V. T. Helker, M. M. Muto, K. M. Savage, S. S. Teerlink, L. A. Jemison, K. M. Wilkinson, and J. E. Jannot. 2022. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2016-2020. U. S. Dept. of

- Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA. NOAA Technical Memorandum NMFS-AFSC-442, 116 p.
- 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.
- 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.
- Frölicher, T. L., E. M. Fischer, and N. Gruber. 2018. Marine heatwaves under global warming. Nature 560(7718):360-364.
- Frost, K. J. 1985. The ringed seal (*Phoca hispida*). Pages 79-87 in J. J. Burns, K. J. Frost, and L. F. Lowry, editors. Marine Mammal Species Accounts. Alaska Department of Fish and Game, 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.
- Frouin-Mouy, H., D. Zeddies, and M. Austin. 2016. Passive Acoustic Monitoring Study: Hilcorp's 2015 Geohazard Survey in Foggy Island Bay, AK.
- Frouin-Mouy, H., X. Mouy, B. Martin, and D. Hannay. 2016. Underwater acoustic behavior of bearded seals (*Erignathus barbatus*) in the northeastern Chukchi Sea, 2007–2010. Marine Mammal Science 32(1):141-160.
- 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., D. S. Ireland, R. Rodrigues, and W. R. Koski, editors. 2010a. Joint monitoring program in the Chukchi and Beaufort seas, 2006-2008, LGL Alaska Report P1050-2. LGL Alaska Research Associates, LGL Limited, Greeneridge Sciences, and JASCO Research.
- Funk, D. W., R. Rodrigues, D. S. Ireland, and W. R. Koski. 2010b. 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, LGL Alaska Report P1050-2.

- Gadamus, L., J. Raymond-Yakoubian, R. Ashenfelter, A. Ahmasuk, V. Metcalf, and G. Noongwook. 2015. Building an indigenous evidence-base for tribally-led habitat conservation policies. *Marine Policy* 62:116-124.
- 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.
- 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. North Pacific Fishery Management Council, Anchorage, AK., 1620 p.
- 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, Tromsø, Norway, 30 May-12 June 2011, 14.
- 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., L. M. Philo, K. Hazard, D. Withrow, G. M. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on

- bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. Arctic 47(3):247-255.
- George, J. C., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayer, B. T. Person, T. Sformo, and R. Suydam. 2017a. 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., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayer, B. T. Person, T. Sformo, and R. Suydam. 2017b. Frequency of Injuries from Line Entanglements, Killer Whales, and Ship Strikes on Bering-Chukchi-Beaufort Seas Bowhead Whales. Arctic 70(1):37-46.
- 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., 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 T. Smith. 1976. Direct and Indirect Effects of Oil on Ringed Seals (*Phoca hispida*) of the Beaufort Sea. Journal of the Fisheries Research Board of Canada 33:1976-1984.
- 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).
- 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. 2016. Horvitz–Thompson whale abundance estimation adjusting for uncertain recapture, temporal availability variation, and intermittent effort. Environmetrics 27(3):134-146.
- Givens, G. H., J. C. George, R. Suydam, B. Tudor, A. L. Von Duyke, and B. Person. 2023. Correcting the 2019 survey abundance of Bering-Chukchi-Beaufort seas bowhead whales for disturbance from powered skiffs. J. Cetacean Res. Manage. 24:47-61.
- 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.
- Goetz, K. T., K. E. W. Shelden, C. L. Sims, J. M. Waite, and P. R. Wade. 2023. Abundance of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2021 and June 2022. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA, May 2023. AFSC Processed Report 2023-03, 47 p.

- 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.
- Goodwin, L., and P. A. Cotton. 2004. Effects of boat traffic on the behaviour of bottlenose dolphins (*Tursiops truncatus*). *Aquatic Mammals* 30(2):279-283.
- Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98(3):1279-91.
- Gordon, J., D. Gillespie, J. Potter, A. Frantz, 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.
- Grebmeier, J. M., J. E. Overland, S. E. Moore, E. V. Farley, E. C. Carmack, L. W. Cooper, K. E. Frey, J. H. Helle, F. A. McLaughlin, and S. L. McNutt. 2006. A major ecosystem shift in the northern Bering Sea. *Science* 311(5766):1461-1464.
- 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. 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 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.
- Greene, C. R. J., 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, San Diego, CA.
- Gryba, R., H. P. Huntington, A. Von Duyke, B. Adams, B. Frantz, J. Gatten, Q. Harcharek, H. Olemaun, R. Sarren, and J. Skin. 2021. Indigenous Knowledge of bearded seal (*Erignathus barbatus*), ringed seal (*Pusa hispida*), and spotted seal (*Phoca largha*) behaviour and habitat use near Utqiagvik, Alaska, USA. *Arctic Science* 7(4):832-858.

- Gulland, F. M. D., J. D. Baker, M. Howe, E. LaBrecque, L. Leach, S. E. Moore, R. R. Reeves, and P. O. Thomas. 2022. A review of climate change effects on marine mammals in United States waters: Past predictions, observed impacts, current research and conservation imperatives. *Climate Change Ecology* 3:100054.
- Hain, J., R. Carter, D. Kraus, A. Mayo, and E. Winni. 1982a. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. *Fishery Bulletin* 80(2):259-268.
- Hain, J., R. Carter, D. Kraus, A. Mayo, and E. Winni. 1982b. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. *Fishery Bulletin* 80(2).
- 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.
- Hammill, M. O., C. Lydersen, M. Ryg, and T. G. Smith. 1991. Lactation in the ringed seal (*Phoca hispida*). *Canadian Journal of Fisheries and Aquatic Sciences* 48(12):2471-2476.
- Hannay, D. E., J. Delarue, X. Mouy, B. S. Martin, D. Leary, J. N. Oswald, and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007–July 2011. *Continental Shelf Research* 67:127-146.
- Hansen, D. J. 1985. The Potential Effects of Oil Spills and Other Chemical Pollutants on Marine Mammals Occurring in Alaskan Waters. USDO, MMS, Alaska OCS Region, Anchorage, AK, 22.
- 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., T. G. Smith, and H. Melling. 2007. Assessing the potential effects of near shore hydrocarbon exploration on ringed seals in the Beaufort Sea region 2003-2006. *Environmental Research Studies Funds*, 103.
- Hastings, K. K., T. S. Gelatt, J. M. Maniscalco, L. A. Jemison, R. Towell, G. W. Pendleton, and D. S. Johnson. 2023. Reduced survival of Steller sea lions in the Gulf of Alaska following marine heatwave. *Frontiers in Marine Science* 10:1127013.
- Hastings, K. K., L. A. Jemison, G. W. Pendleton, K. L. Raum-Suryan, and K. W. Pitcher. 2017. Natal and breeding philopatry of female Steller sea lions in southeastern Alaska. *PLoS One* 12(6):e0176840.
- Hastings, K. K., M. J. Rehberg, G. M. O'Corry-Crowe, G. W. Pendleton, L. A. Jemison, and T. S. Gelatt. 2020. Demographic consequences and characteristics of recent population mixing and colonization in Steller sea lions, *Eumetopias jubatus*. *Journal of Mammalogy* 101(1):107-120.
- Hastings, M. C., and A. N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Sacramento, California, 1/28/2005, 82.

- 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., K. J. Frost, and J. J. Burns. 2021. Ringed seal (*Pusa hispida*) breeding habitat on the landfast ice in northwest Alaska during spring 1983 and 1984. *PLoS One* 16(11):e0260644.
- 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, 180.
- 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.
- Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2019. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016. U. S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Seattle, WA, May 2019. NOAA Tech. Memo. NMFS-AFSC-392, 71 p.
- Hendrix, A. M., K. A. Lefebvre, L. Quakenbush, A. Bryan, R. Stimmelmayer, G. Sheffield, G. Wisswaesser, M. L. Willis, E. K. Bowers, and P. Kendrick. 2021. Ice seals as sentinels for algal toxin presence in the Pacific Arctic and subarctic marine ecosystems. *Marine Mammal Science* 37(4):1292-1308.
- 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, II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti*. 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.
- High Tide Environmental. 2018. Final observer report for the Unalaska Marine Center dock replacement, City of Unalaska, Alaska. Prepared for NMFS, Office of Protected Resources, by High Tide Environmental, Wasilla, AK.
- Hilcorp. 2017. Weekly Reports, Middle Ground Shoal Platform Natural Gas Pipeline Release, May-June 2017. .
- Hinch, S. G., S. J. Cooke, A. P. Farrell, K. M. Miller, M. Lapointe, and D. A. Patterson. 2012. Dead fish swimming: a review of research on the early migration and high premature mortality in adult Fraser River sockeye salmon *Oncorhynchus nerka*. J Fish Biol 81(2):576-99.
- 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. Shelden. 2008. Supplemental status review and extinction assessment of Cook Inlet belugas (*Delphinapterus leucas*). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, October 2008. AFSC Processed Report 2008-08, 76 p.
- 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.
- Holmes, E., and A. York. 2003. Using age structure to detect impacts on threatened populations: a case study with Steller sea lions. Conservation Biology 17(6):1794-1806.
- 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., 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
- Houseknecht, D. W., R. O. Lease, C. J. Schenk, T. J. Mercier, W. A. Rouse, P. J. Jarboe, K. J. Whidden, C. P. Garrity, K. A. Lewis, S. J. Heller, W. H. Craddock, T. R. Klett, P. A. Le, R. A. Smith, M. E. Tennyson, S. B. Gaswirth, C. A. Woodall, M. E. Brownfield, H. M. Leathers-Miller, and T. M. Finn. 2017. Assessment of undiscovered oil and gas resources in the cretaceous Nanushuk and Torok formations, Alaska North Slope, and summary of

- resource potential of the National Petroleum Reserve in Alaska, 2017. U. S. Geological Survey Fact Sheet 2017-3088. U.S. Geological Survey, Reston, VA, December 22, 2017.
- 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. *The Journal of the Acoustical Society of America* 120(6):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.
- Houser, D. S., K. Moore, S. Sharp, J. Hoppe, and J. J. Finneran. 2018. Cetacean evoked potential audiometry by stranding networks enables more rapid accumulation of hearing information in stranded odontocetes. *Journal of Cetacean Research and Management* 18:93-101.
- 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*). *Gen Comp Endocrinol* 148(2):260-272.
- Huntington, H. P. 2000. Using traditional ecological knowledge in science: methods and applications. *Ecological Applications* 10(5):1270-1274.
- Huntington, H. P., S. L. Danielson, F. K. Wiese, M. Baker, P. Boveng, J. J. Citta, A. De Robertis, D. M. Dickson, E. Farley, and J. C. George. 2020. Evidence suggests potential transformation of the Pacific Arctic ecosystem is underway. *Nature Climate Change* 10(4):342-348.
- Ice Seal Committee. 2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2017, Approved by ISC on May 31, 2019, 86 p.
- Illingworth & Rodkin. 2017. Pile-driving noise measurements at Atlantic Fleet Naval Installations: 28 May 2013–28 April 2016, Submitted to Naval Facilities Engineering Command Atlantic under HDR Environmental, Operations and Construction, Inc., 152 p.
- Illingworth & Rodkin, I. 2014. Anchorage Port modernization project, underwater noise monitoring plan. Prepared for CH2M Hill Engineers, Inc., Project No. 14-141. 43 pp.
- 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. 2019. Technical summary. Pages 39-69 in H.-O. Pörtner, and coeditors, editors. H.-O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegira, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N. M. Weyer, editors, *Special report on the ocean and cryosphere in a changing climate*. Cambridge University Press, New York, NY.
- IPCC. 2021. *Climate change 2021: The physical science basis. Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, New York.

- Ivashchenko, Y. V., R. L. Brownell Jr., and P. J. Clapham. 2014. Distribution of Soviet catches of sperm whales *Physeter macrocephalus* in the North Pacific. *Endangered Species Research* 25(3):249-263.
- Jacobs Engineering. 2017a. Biological Evaluation for Offshore Oil and Gas Exploratory Drilling in the Kitchen Lights Unit of Cook Inlet, Alaska. Developed for Furie Operating Alaska, LLC. Prepared for Furie Operating Alaska, LLC., Anchorage, AK, March 2017, 157 p.
- Jacobs Engineering. 2017b. Biological Evaluation for Offshore Oil and Gas Exploratory Drilling in the Kitchen Lights Unit of Cook Inlet, Alaska. Developed for Furie Operating Alaska, LLC., 157.
- Jacobs Engineering Group. 2019. 2018 Marine mammal monitoring 90-day report for natural gas well development drilling at the julius R platform Cook Inlet, Alaska. Developed for Furie Operating Alaska, LLC, Anchorage, AK, January 2019, 169 p.
- 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*, 09-01. Alaska Sea Grant College Program, University of Alaska Fairbanks.
- Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. .
- 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.
- John, J. S., D. R. Christen, K. L. Flammer, T. L. Kendall, E. C. Nazario, B. P. Richter, V. Gill, and T. M. Williams. 2024. Conservation energetics of beluga whales: Using resting and swimming metabolism to understand threats to an endangered population. *Journal of Experimental Biology* 227(5).
- 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. 2014a. Ringed, Bearded, and Ribbon Seal Vocalizations North of Barrow, Alaska: Seasonal Presence and Relationship with Sea Ice. *Arctic* 67:203-222.
- Jones, J. M., B. J. Thayre, E. H. Roth, M. Mahoney, I. A. N. Sia, K. Mercurief, C. Jackson, C. Zeller, M. Clare, A. Bacon, S. Weaver, Z. O. E. Gentes, R. J. Small, I. A. N. Stirling, S. M. Wiggins, J. A. Hildebrand, and N. Giguère. 2014b. Ringed, bearded, and ribbon seal vocalizations north of Barrow, Alaska: seasonal presence and relationship with sea ice. *Arctic* 67(2):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*.
- Kastelein, R. A., R. Van Schie, W. C. Verboom, and D. de Haan. 2005. Underwater hearing sensitivity of a male and a female Steller sea lion (*Eumetopias jubatus*). *Journal of the Acoustical Society of America* 118(3):1820-1829.
- Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. *Scientific Reports of the Whales Research Institute, Tokyo* 39:31-75.
- 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, 6.
- Kawamura, A. 1980a. A review of food of balaenopterid whales. *Sci. Rep. Whales Res. Inst* 32:155-197.
- Kawamura, A. 1980b. A review of food of balaenopterid whales. *Scientific Reports of the Whales Research Institute* 32:155-197.
- Kelly, B. P. 1988. Ringed seal, *Phoca hispida*. Pages 57-75 in J. W. Lentfer, editor. *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*. Marine Mammal Commission, Washington, D.C.
- Kelly, B. P. 2022. The ringed seal: behavioral adaptations to seasonal ice and snow cover. Pages 553-597 in D. P. Costa, and E. A. McHuron, editors. *Ethology and behavioral ecology of phocids*. Springer International Publishing, Cham, Switzerland.
- Kelly, B. P., O. H. Badajos, M. Kunasranta, 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. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, December 2010. NOAA Technical Memorandum NMFS-AFSC-212, 250 p.

- 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. 2010c. Status review of the ringed seal (*Phoca hispida*). U.S. Department of Commerce, Seattle, WA, 250.
- 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. 2015a. 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., K. Lomac-MacNair, G. Campbell, S. Wisdom, and N. Wolf. 2015b. SAEExploration 2015 Cook Inlet 3D seismic surveys: marine mammal monitoring and mitigation 90-day report. Prepared by Fairweather Science for National Marine Fisheries Service Permits and Conservation Division Office of Protected Resources, Anchorage, AK, December 29, 2015.
- 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.
- Keple, A. R. 2002. Seasonal abundance and distribution of marine mammals in the southern Strait of Georgia, British Columbia. University of British Columbia.
- 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.
- Kinney, J. C., W. Maslowski, R. Osinski, Y. J. Lee, C. Goethel, K. Frey, and A. Craig. 2022. On the variability of the Bering Sea cold pool and implications for the biophysical environment. PLoS One 17(4).
- 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.

- Kucey, L. 2005. Human disturbance and the hauling out behavior of steller sea lions (*Eumetopias jubatus*). University of British Columbia, British Columbia.
- Kuletz, K. J., S. H. Ferguson, M. Frederiksen, C. P. Gallagher, D. D. W. Hauser, H. Hop, K. M. Kovacs, C. Lydersen, A. Mosbech, and A. C. Seitz. 2024. A review of climate change impacts on migration patterns of marine vertebrates in Arctic and subarctic ecosystems. *Frontiers in Environmental Science* 12.
- Kumar, S. V., M. Castellote, and V. Gill. 2024. The urban beluga acoustic monitoring in the Kenai and Kasilof Rivers, Alaska, Anchorage. CS Study BOEM 2024-002. Contract No.: M20PG00005.
- 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.
- Lawrence, C. B., G. A. Warner, and M. E. Austin. 2022. Underwater sound measurements of tugs towing a jack-up rig: Cook Inlet, Fall 2021, Document 02561, v.1, Technical report by JASCO Applied Sciences for Hilcopr Alaska, February 2, 2022, 31 p.
- Lee, J. S., S. Tanabe, H. Umino, R. Tatsukawa, T. R. Loughlin, and D. C. Calkins. 1996. Persistent organochlorines in Steller sea lion (*Eumetopias jubatus*) from the bulk of Alaska and the Bering Sea, 1976-1981. *Marine Pollution Bulletin* 32(7):535-544.
- 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.
- Lesage, V., C. Barrette, M. C. S. Kingsley, and B. Sjare. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada. *Marine Mammal Science* 15(1):65-84.

- 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., 320.
- Lindsay, J. M., K. L. Laidre, P. B. Conn, E. E. Moreland, and P. L. Boveng. 2021. Modeling ringed seal *Pusa hispida* habitat and lair emergence timing in the eastern Bering and Chukchi seas. *Endangered Species Research* 46:1-17.
- Lischka, S., and U. Riebesell. 2012. Synergistic effects of ocean acidification and warming on overwintering pteropods in the Arctic. *Global Change Biology* 18(12):3517-3528.
- Litzow, M. A., K. M. Bailey, F. G. Prahl, and R. Heintz. 2006. Climate regime shifts and reorganization of fish communities: the essential fatty acid limitation hypothesis. *Marine Ecology Progress Series* 315:1-11.
- 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, 187.
- 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, December 2, 2014.
- 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.
- 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. Report prepared for SAExploration, Inc, by Smultea Environmental Sciences, P.O. Box 256, Preston, WA 98050. December 15, 2014., Preston, WA, December 2, 2014.

- 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.
- Loughlin, T. R., and T. S. Gelatt. 2017. Steller sea lion *Eumetopias jubatus*. Pages (Ebook) 2491-2499 in B. Würsig, J. G. M. Thewissen, and K. M. Kovacs, editors. Encyclopedia of marine mammals. Academic Press, San Diego, CA.
- Loughlin, T. R., D. J. Rugh, and C. H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-80. Journal of Wildlife Management 48(3):729-740.
- Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion, *Eumetopias jubatus*, mortality. Marine Fisheries Review 62(4):40-45.
- 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, Society for Marine Mammalogy Special Publication Number 2. Allen Press, Inc., Lawrence, KS.
- 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.
- Lukin, L. R., and V. A. Potelov. 1978. Living conditions and distribution of ringed seal in the White Sea in the winter. Soviet Journal of Marine Biology 4(3):684-690.
- Luksenburg, J. A., and E. C. M. Parsons. 2009. The effects of aircraft on cetaceans: implications for aerial whalewatching, 2009.
- Luque, S. P., S. H. Ferguson, and G. A. Breed. 2014. Spatial behaviour of a keystone Arctic marine predator and implications of climate warming in Hudson Bay. Journal of Experimental Marine Biology and Ecology 461:504-515.
- Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22(4):802-818.
- 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. 1998. Status and biology of ringed seals (*Phoca hispida*) in Svalbard. Pages 46-62 in M. P. Heide-Jorgensen, and C. Lydersen, editors. Ringed Seals in the North Atlantic. NAMMCO Scientific Publications.
- 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, 1987, 89-112.
- 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, 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. 2015a. 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.
- MacIntyre, K. Q., K. M. Stafford, P. B. Conn, K. L. Laidre, and P. L. Boveng. 2015b. 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.
- 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, 393-600.
- 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.
- Mansfield, A. W. 1983. The effects of vessel traffic in the Arctic on marine mammals and recommendations for future research., Canadian Technical Report of Fisheries and Aquatic Sciences 1186, Quebec, 107 p.
- Marcogliese, D. J. 2001. Implications of climate change for parasitism of animals in the aquatic environment. Canadian Journal of Zoology 79(8):1331-1352.
- Marine Exchange of Alaska. 2024. Bering Strait and Arctic transits, <https://library.arcticportal.org/2885/>, March 26, 2025.
- Marquette, W. M., and J. R. Bockstoe. 1980. Historical shore-based catch of bowhead whales in the Bering, Chukchi, and Beaufort seas. Marine Fisheries Review 1980(Sep-Oct):5-19.
- 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). The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology 288(1):13-25.
- Martins, E. G., S. G. Hinch, D. A. Patterson, M. J. Hague, S. J. Cooke, K. M. Miller, D. Robichaud, K. K. English, and A. P. Farrell. 2012. High river temperature reduces survival of sockeye salmon (*Oncorhynchus nerka*) approaching spawning grounds and exacerbates female mortality. Canadian Journal of Fisheries and Aquatic Sciences 69(2):330-342.

- 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.
- Matkin, C. O. 2011. Predation by killer whales in Cook Inlet and Western Alaska: an integrated approach 2008-2009, Project R0303-01 Final Report, Homer, AK, Revised April 2011.
- Matsuoka, K., S. A. Mizroch, and H. Komiya. 2013. Cruise report of the 2012 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). International Whaling Commission, Cambridge, 43 p.
- Mauger, S., R. Shaftel, J. C. Leppi, and D. J. Rinella. 2017. Summer temperature regimes in southcentral Alaska streams: watershed drivers of variation and potential implications for Pacific salmon. *Canadian Journal of Fisheries and Aquatic Sciences* 74(5):702-715.
- 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, 188.
- 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., J. McClung, and A. Willoughby. 2023. Photo-identification of beluga whales in Cook Inlet, Alaska. Summary of field activities and whales identified in 2021. Report prepared by Cook Inlet Beluga Whale Photo-ID Project for NMFS, Alaska Region.
- 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, 30 plus appendices.

- 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, 92 p.
- McGuire, T., A. Stephens, J. McClung, C. Garner, K. Shelden, G. Himes Boor, and B. Wright. 2020a. Reproductive natural history of endangered Cook Inlet Beluga whales: insights from a long-term photo-identification study. *Polar Biology* 43:1851-1871.
- McGuire, T. L., G. K. Himes Boor, J. R. McClung, A. D. Stephens, C. Garner, K. E. W. Shelden, and B. Wright. 2020b. Distribution and habitat use by endangered Cook Inlet beluga whales: Patterns observed during a photo-identification study, 2005–2017. *Aquatic Conservation: Marine and Freshwater Ecosystems* 30(12):2402-2427.
- McGuire, T. L., K. E. W. Shelden, G. K. Himes Boor, A. D. Stephens, J. R. McClung, C. Garner, C. E. C. Goertz, K. A. Burek-Huntington, G. O'Corry-Crowe, and B. Wright. 2021. Patterns of mortality in endangered Cook Inlet beluga whales: Insights from pairing a long-term photo-identification study with stranding records. *Marine Mammal Science* 37:492-511.
- McGuire, T. L., and A. Stephens. 2016. Summary Report: Status of previously satellite tagged Cook Inlet beluga whales. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, June 13, 2016, 86 p.
- McGuire, T. L., A. D. Stephens, J. R. McClung, C. Garner, K. A. Burek-Huntington, C. E. C. Goertz, K. E. W. Shelden, G. O'Corry-Crowe, G. K. H. Boor, and B. Wright. 2020c. Anthropogenic scarring in long-term photo-identification records of Cook Inlet beluga whales, *Delphinapterus leucas*. *Marine Fisheries Review* 82(3-4):20-40.
- Meier, W. N., and J. Stroeve. 2022. An updated assessment of the changing Arctic sea ice cover. *Oceanography* 35(3-4):10-19.
- 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.
- Melnikov, V., and I. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. *Marine Mammal Science* 21(3):550-556.
- Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. *Canadian Journal of Zoology* 75(5):776-786.
- Migura, M., and C. Bollini. 2022. To take or not take? Examination of the status quo process for issuing take authorizations of endangered Cook Inlet beluga whales and implications for their recovery. *Conservation Science and Practice* 4(2):e590.
- 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.
- Miller, P. J. O., M. P. Johnson, and P. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society of London. Series B: Biological Sciences* 271:2239-2247.
- Mizroch, S., and D. Rice. 2013. Ocean nomads: Distribution and movements of sperm whales in the North Pacific shown by whaling data and Discovery marks. *Marine Mammal Science* 29:E136-E165.
- 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*, 118.
- Möhl, 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.
- Mohseni, O., and H. Stefan. 1999. Stream temperature/air temperature relationship: a physical interpretation. *Journal of hydrology* 218(3-4):128-141.
- 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. J. Burns, J. J. Montague, and C. J. Cowles, editors. *The bowhead whale*, Society of Marine Mammalogy Special Publication 2. Allen Press, Inc., Lawrence, KS.
- 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.
- 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. 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). Pages 5-1-5-66 in 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. LGL Report TA2428-3 prepared by LGL Environmental Research Associates and Greeneridge Sciences for BP Exploration (Alaska) and National Marine Fisheries Service.
- Moulton, V. D., R. E. Elliott, W. J. Richardson, and T. L. McDonald. 2002. 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. Pages 5-1-5-60 in 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, 2001. LGL Report TA2570-3 prepared by LGL Environmental Research Associates and Greenridge Sciences for BP Exploration (Alaska) and National Marine Fisheries Service.
- Moulton, V. D., R. E. Elliott, and M. T. Williams. 2003. Fixed-wing aerial surveys near BP's Northstar and Liberty sites, 2002. Pages 4-1-4-35 in 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, 1999-2002. LGL Report TA2707-5 prepared by LGL Environmental Research Associates and Greenridge Sciences for BP Exploration (Alaska) and National Marine Fisheries Service.
- 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, R. E. Elliott, T. L. McDonald, C. Nations, and M. T. Williams. 2005. Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea. *Marine Mammal Science* 21(2):217-242.

- Mueter, F. J., C. Broms, K. F. Drinkwater, K. D. Friedland, J. A. Hare, G. L. Hunt Jr, W. Melle, and M. Taylor. 2009. Ecosystem responses to recent oceanographic variability in high-latitude Northern Hemisphere ecosystems. 81:18.
- Mulsow, J., and C. Reichmuth. 2010. Psychophysical and electrophysiological aerial audiograms of a Steller sea lion (*Eumetopias jubatus*). The Journal of the Acoustical Society of America 127(4):2692-2701.
- 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. 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, Alaska Fisheries Science Center 7600 Sand Point Way N.E. Seattle, WA 98115.
- Muto, M. M., V. T. Helker, R. P. Angliss, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. 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, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2019. Alaska marine mammal stock assessments, 2018. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, June 2019. NOAA Technical Memorandum NMFS-AFSC-393, 390 p.
- Muto, M. M., V. T. Helker, B. J. Delean, N. C. Young, J. C. Freed, R. P. Angliss, N. A. Friday, P. L. Boveng, J. M. Breiwick, B. M. Brost, M. F. Cameron, P. J. Clapham, J. L. Crance, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, K. T. Goetz, 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, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2021. Alaska marine mammal stock assessments, 2020. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, July 2021. NOAA Technical Memorandum NMFS-AFSC-421, 398 p.
- 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, WA.

- 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.
- 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., C. Gabriele, J. Straley, S. Hills, and J. Robbins. 2005. Humpback whale entanglement rates in southeast Alaska. Pages 203-204 in Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
- Neilson, J. L., and C. Gabriele. 2020. Glacier Bay and Icy Strait humpback whale population monitoring: 2019 update. U.S. Dept. of Interior, National Park Service, Glacier Bay National Park and Preserve, Gustavus, AK, May 2020. National Park Service Resource Brief, 6 p.
- Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. Straley. 2012a. Summary of Reported Whale-Vessel Collisions in Alaskan Waters. Journal of Marine Biology 2012(Article ID 106282):18.
- Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012b. Summary of reported whale-vessel collisions in Alaskan waters. Journal of Marine Biology 2012:106282.
- 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, A report for the North Slope Borough's Coastal Management Program, North Slope Borough, Alaska, December 1981, 112 p.
- 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, 7. Alaska Department of Fish and Game, Juneau, 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. 1991a. Final recovery plan for the humpback whale (*Megaptera novaeangliae*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 1991b. 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. National Oceanic and Atmospheric Administration, Department of Commerce, , Silver Spring, MD.

- NMFS. 2008a. Conservation plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Alaska Region, Protected Resources Division, Juneau, AK, October 2008, 122 p.
- NMFS. 2008b. Final Conservation Plan for the Cook Inlet beluga whale (*Delphinapterus leucas*), Anchorage, AK.
- NMFS. 2008c. Final Conservation Plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Alaska Region, Protected Resources Division, Juneau, AK, October 2008, 122 p.
- NMFS. 2008d. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Eastern and Western Distinct Population Segments (*Eumetopias jubatus*). Revision. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD, March 2008, 325 p.
- NMFS. 2008e. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Revision. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD, March 2008, 325 p.
- NMFS. 2010a. 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. 2010b. Final recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD, 165 p.
- NMFS. 2010c. Recovery plan for the fin whale (*Balaenoptera physalus*), National Marine Fisheries Service, Silver Spring, MD., 121 p.
- 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. Effects of oil and gas activities in the Arctic Ocean: supplemental draft Environmental Impact Statement. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, March 21, 2013.
- NMFS. 2013c. 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, Juneau, Alaska.
- NMFS. 2013d. Final recovery plan for the North Pacific Right Whale (*Eubalaena japonica*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, 84 p.
- 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. NMFS consultation number: AKR-2014-9383.
- 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. NMFS consultation number: AKR-2014-9370.
- 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, June 10, 2014.
- 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, 342.
- 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, Juneau, Alaska. NMFS consultation number: AKR-2015-9448.
- NMFS. 2016a. 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.
- NMFS. 2016b. 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. 2016c. Recovery plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK, December 2016.
- NMFS. 2016d. Recovery Plan for the Cook Inlet Beluga Whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK.
- NMFS. 2016e. 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. 2016f. U.S. National Bycatch Report First Edition Update 2. U.S. Dept. of Commerce, NOAA, NMFS, February 2016, 90 p.

- 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. AKR-2017-9600.
- NMFS. 2017b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion for Lease Sale 244, Cook Inlet, Alaska 2017-2022, Anchorage, AK.
- NMFS. 2017c. 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. 2018 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-59.
- NMFS. 2018b. Assessment of the Pacific cod stock in the Gulf of Alaska, Seattle, WA.
- NMFS. 2018c. 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. 2018d. Endangered Species Act Section 7 Letter of Concurrence for Furie's offshore oil and gas exploration drilling in the Kitchen Lights Unit of Cook Inlet, Alaska, 2018-2021. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK, May 8, 2018. AKR-2018-9762, 46 p.
- NMFS. 2018e. 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, Anchorage, AK.
- NMFS. 2018f. 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. 2019a. 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., Juneau, Alaska. ECO Number: AKRO-2017-00028.
- NMFS. 2019b. ESA Section 7 Biological and Conference Opinion on the proposed implementation of a program for the issuance of permits for research and enhancement activities on cetaceans in the Arctic, Atlantic, Indian, Pacific, and Southern oceans. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division, Silver Spring, MD.

- NMFS. 2019c. Takes of marine mammals incidental to specified activities; Taking marine mammals incidental to oil and gas activities in Cook Inlet, Alaska. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division, Silver Spring, MD, 37442-37506.
- NMFS. 2019d. U.S. National Bycatch Report First Edition Update 3.
- NMFS. 2020a. 5-year review: summary and evaluation of western Distinct Population Segment Steller sea lion *Eumetopias jubatus*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK, February 2020, 61 p.
- NMFS. 2020b. Biological report for the designation of critical habitat for the Central America, Mexico, and Western North Pacific Distinct Population Segments of humpback whales (*Megaptera novaeangliae*). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, July 2020.
- NMFS. 2020c. Endangered Species Act Section 7 programmatic biological and conference opinion on construction and operation of up to six new icebreakers to support Coast Guard Missions in the Arctic and Antarctic. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, Silver Spring, MD. September 3, 2020. Consultation Tracking Number: OPR-2017-00023.
- NMFS. 2022. Beluga whale - Cook Inlet DPS (*Delphinapterus leucas*) 5-year review: summary and evaluation. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Alaska Region, Protected Resources Division, and Alaska Fisheries Science Center, Marine Mammal Laboratory, Anchorage, AK and Seattle, WA, August 12, 2022.
- NMFS. 2024a. 2024 Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0), Underwater and In-Air Criteria for Onset of auditory Injury and Temporary Threshold Shifts. U.S. Dept of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Springs, MD. NOAA Technical Memorandum NMFS-OPR-71 October 2024
- NMFS. 2024b. 2024 update to: technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 3.0): underwater and in-air criteria for onset of auditory injury and temporary threshold shifts. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. NOAA Tech. Memo. NMFS-OPR-71, 182 p.
- NMFS. 2024c. Endangered Species Act (ESA) section 7(a)(2) biological and section 7(a)(4) conference opinion on the Fishery Management Plan for the groundfish fisheries of the Gulf of Alaska. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region Protected Resources Division, Juneau, AK, December 23, 2024. Consultation Number AKRO-2024-01759, 347 p.

- NMFS. 2024d. Ringed seal 5-year review: summary and evaluation. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division and Alaska Fisheries Science Center, Marine Mammal Laboratory, Juneau, AK, February 2024, 241 p.
- NOAA. 2019. Alaska Fisheries Science Center presentation at the Alaska Eskimo Whaling Commission meeting, October 29, 2019.
- 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. <http://www.psmfc.org/ballast/wordpress/wp-content/uploads/2011/05/Marine-invasive-species-in-the-Arctic-Norden-2014.pdf>. 9/20/16.
- 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 National Marine Fisheries Service under contract number HA133F-10-SE-3639, Anchorage, AK, September 2011, 113 p.
- Norman, S. A., R. C. Hobbs, L. A. Beckett, S. J. Trumble, and W. A. Smith. 2020. Relationship between per capita births of Cook Inlet belugas and summer salmon runs: age-structured population modeling. *Ecosphere* 11(1):e02955.
- Norman, S. A., R. C. Hobbs, C. E. Goertz, K. A. Burek-Huntington, K. E. Sheldon, 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 Arctic Borough. 2016. Important areas for marine and coastal species. Pages 415-529 in *Iñuunialiqput Ililugu Nunanñuanun: Documenting our way of life through maps*. Northwest Arctic Borough, Kotzebue, Alaska.
- 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. Jasny, 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. 2003a. Ocean Noise and Marine Mammals. National Academy Press, Washington, D.C.
- NRC. 2003b. Ocean Noise and Marine Mammals. National Research Council, Ocean Study Board, National Academy Press, Washington, D.C.
- Nuka Research and Planning Group. 2015. 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.
- 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.
- Oceana and Kawerak. 2014. Bering Strait marine life and subsistence use data synthesis, July 2014.
- Olness, J., J. J. Citta, L. T. Quakenbush, J. C. George, L. A. Harwood, E. V. Lea, and M. P. Heide-Jørgensen. 2020a. Use of the Alaskan Beaufort Sea by bowhead whales (*Balaena mysticetus*) tagged with satellite transmitters, 2006–18. *Arctic* 73(3):278-291.
- Olness, J., J. Crawford, J. J. Citta, M. L. Druckenmiller, A. L. Von Duyke, and L. Quakenbush. 2020b. Movement, diving, and haul-out behaviors of juvenile bearded seals in the Bering, Chukchi and Beaufort seas, 2014–2018. *Polar Biology* 43:1307-1320.
- 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.
- 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.
- 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.
- 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 by Owl Ridge Natural Resource Consultants for BlueCrest Alaska Operating LLC, Anchorage, AK, Sept. 26, 2014.
- 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.
- Parkinson, C. L. 2022. Arctic sea ice coverage from 43 years of satellite passive-microwave observations. *Frontiers in Remote Sensing* 3:1021781.
- 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, 3.
- 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.
- Patenaude, N. J., W. J. Richardson, M. A. Smultea, W. R. Koski, G. W. Miller, B. Wursig, and C. R. Greene. 2002a. 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., W. J. Richardson, M. A. Smultea, W. R. Koski, G. W. Miller, B. Würsig, and C. R. Greene Jr. 2002b. 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.
- Payne, R. S. 1970. Songs of the humpback whale. Capitol Records, Hollywood, CA.
- Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The Great Whales: History and Status of Six Species Listed as Endangered Under the U.S. Endangered Species Act of 1973: a special issue of the Marine Fisheries Review. *Marine Fisheries Review* 61(1):1-74.
- 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. 1993a. Morbidity and mortality. Pages 275-312 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The bowhead whale. The Society for Marine Mammalogy, Special Publication 2. Allen Press, Lawrence, Kansas.
- Philo, L. M., E. Shotts, and J. C. George. 1993b. Morbidity and mortality. The bowhead whale. *Soc. Mar. Mammal., Spec. Publ* (2):275-312.
- Pilfold, N. W., A. E. Derocher, I. Stirling, and E. Richardson. 2014. Polar bear predatory behaviour reveals seascape distribution of ringed seal lairs. *Population Ecology* 56(1):129-138.
- 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.
- Pitcher, K. W., and D. G. Calkins. 1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. *Journal of Mammalogy* 62(3):599-605.
- Pitcher, K. W., and F. H. Fay. 1982. Feeding by Steller sea lions on harbor seals. *The Murrelet*:70-71.
- POA. 2003. Environmental baseline survey for the Port of Anchorage road and rail extension right of way. U.S. Army Defense Fuels Property.
- POA. 2019a. June 2019 marine mammal observation report, Report submitted by Port of Alaska NMFS, Anchorage, AK, July 15, 2019.
- POA. 2019b. 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.
- Posdaljian, N., A. Solsona-Berga, J. A. Hildebrand, C. Soderstjerna, S. M. Wiggins, K. Lenssen, and S. Baumann-Pickering. 2024. Sperm whale demographics in the Gulf of Alaska and Bering Sea/Aleutian Islands: an overlooked female habitat. *PLoS One* 19(7):e0285068.
- 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).
- Qi, D., L. Chen, B. Chen, Z. Gao, W. Zhong, Richard A. Feely, Leif G. Anderson, H. Sun, J. Chen, M. Chen, L. Zhan, Y. Zhang, and W.-J. Cai. 2017. Increase in acidifying water in the western Arctic Ocean. *Nature Climate Change* 7(3):195-199.
- Quakenbush, L. 2018. Tagged Bowhead Whale Data in respects to Liberty Project. B. Easley-Appleyard, editor.
- Quakenbush, L. 2020a. Biological monitoring of ice seals in Alaska to determine health and status of populations—diet, disease, contaminants, reproduction, body condition, growth, and age at maturity. Alaska Department of Fish and Game, Fairbanks, AK.
- Quakenbush, L. 2020b. Movements and habitat use of Pacific Arctic seals and whales via satellite telemetry and ocean sensing. Alaska Department of Fish and Game, Arctic Marine Mammal Program, Fairbanks, AK. Report to Office of Naval Research, Award 00014-16-1-3019, 91 p.
- Quakenbush, L., A. Bryan, J. Crawford, and J. Olnes. 2020. Biological monitoring of ringed seals in the Bering and Chukchi seas, Final report to National Marine Fisheries Service for Award No. NA16NMF4720079, 33 p.
- Quakenbush, L., J. Citta, and J. Crawford. 2011. Biology of the ringed seal (*Phoca hispida*) in Alaska, 1960-2010. Final report from Alaska Dept. of Fish and Game Arctic Marine Mammal Program to the National Marine Fisheries Service, Fairbanks, AK.
- Quakenbush, L., J. Citta, J. C. George, M. P. Heide-Jørgensen, R. Small, H. Brower, L. Harwood, B. Adams, L. Brower, and G. Tagarook. 2012. Seasonal movements of the Bering-Chukchi-Beaufort stock of bowhead whales: 2006–2011 satellite telemetry results. Report to the International Whaling Commission Scientific Committee SC/64/BRG1.
- 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. *Marine Fisheries Review* 77:70-84.
- Quakenbush, L. T., J. A. Crawford, M. A. Nelson, and J. R. Olnes. 2019a. 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. Prepared by the Alaska Department of Fish and Game under BOEM Contract M13PC0015 for U.S. Dept. of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Juneau, AK, November 2019. OCS Study BOEM 2019-079, 131 p. + appendices.
- Quakenbush, L. T., J. A. Crawford, M. A. Nelson, and J. R. Olnes. 2019b. 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.
- Rantanen, M., A. Y. Karpechko, A. Lipponen, K. Nordling, O. Hyvärinen, K. Ruosteenoja, T. Vihma, and A. Laaksonen. 2022. The Arctic has warmed nearly four times faster than the globe since 1979. *Communications Earth & Environment* 3(1).
- 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.
- Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. *Marine Mammal Science* 18(3):746-764.
- Raum-Suryan, K. L., M. J. Rehberg, G. W. Pendleton, K. W. Pitcher, and T. S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. *Marine Mammal Science* 20(4):823-850.
- 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., C. Rosa, J. C. George, G. Sheffield, and M. Moore. 2012. Implications of Arctic industrial growth and strategies to mitigate future vessel and fishing gear impacts on bowhead whales. *Marine Policy* 36(2):454-462.
- 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, 240.
- Rendell, L., and H. Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour* 67:865-874.
- Research, N. 2022. Characterization Report of Vessel Activity in Cook Inlet for 2011-2020. <https://nukaresearch.com/projects/characterization-report-of-vessel-activity-in-cook-inlet-for-2011-2020/>. 9/22/2025.
- Rexford, B. 1997. A native whaler's view. <http://www.alaska.boemre.gov/native/rexford/rexford.htm>.
- 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*, 4. Academic Press, New York, New York.
- 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, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK, and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD, November 1998, 318 p.
- 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, 390.
- 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. 1995a. *Marine Mammals and Noise*. Academic Press, Inc., San Diego, CA.
- Richardson, W. J., C. R. Greene Jr, C. I. Malme, and D. H. Thomson. 1995b. *Marine mammals and noise*. Academic Press, Inc., San Diego, CA.
- Richardson, W. J., and C. I. Malme. 1993a. 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 C. I. Malme. 1993b. Man-made noise and behavioral responses. Pages 631-700 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale, Special Publication Number 2. Society for Marine Mammology, Allen Press, Inc., Lawrence, KS.
- Richardson, W. J., and C. I. Malme. 1993c. 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 Special Publication Number 2. Allen Press, Inc., Lawrence, KS.
- Richardson, W. J., and M. T. Williams. 2002. Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2002. LGL Research Associates and Greenride Sciences Inc. , 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.
- Richter-Menge, J., M. L. Druckenmiller, and M. Jeffries, editors,. 2019. Arctic Report Card 2019, <http://www.arctic.noaa.gov/Report-Card>.
- Richter-Menge, J., J. E. Overland, J. T. Mathis, and E. Osborne, editors. 2017. Arctic report card 2017, https://arctic.noaa.gov/wp-content/uploads/2023/04/ArcticReportCard_full_report2017.pdf.
- 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.
- 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, Seattle, WA. NOAA Technical Memorandum NMFS-AFSC-149, 71 p.
- 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.
- Ryg, M., T. G. Smith, and N. A. Øritsland. 1990. Seasonal changes in body mass and body composition of ringed seals (*Phoca hispida*) on Svalbard. *Canadian Journal of Zoology* 68(3):470-475.
- 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. Wetzel, and J. E. Reynolds. 2014a. 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., Final report of field surveys and laboratory analyses (2011-2013) prepared by Cook Inlet Regional Citizens Advisory Council (RCAC) for the Kenai Peninsula Borough, February 2014, 53 p.
- Saupe, S. M., T. M. Willette, D. L. Wetzel, and J. E. Reynolds. 2014b. 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.
- 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.

- Scheifele, P. M., S. Andrew, R. A. Cooper, M. Darre, F. E. Musiek, and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. *The Journal of the Acoustical Society of America* 117(3):1486-1492.
- Scheimreif, K., J. Citta, R. Stimmelmayer, R. Acker, P. Anashugak, A. L. Von Duyke, T. L. Sformo, B. T. Person, F. J. Olemaun, L. Sousa, N. Wojciechowski, and J. C. George. 2023. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2022. International Whaling Commission, Scientific Committee, Document SC/69A/ASW/02.
- Scheimreif, K., J. Citta, R. Stimmelmayer, R. Frantz, P. Anashugak, L. Sousa, A. L. Von Duyke, T. L. Sformo, B. T. Person, and F. J. Olemaun. 2024. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2023. International Whaling Commission, Scientific Committee, Document SC/69B/ASW/02 Rev1.
- Scheimreif, K., J. Citta, R. Stimmelmayer, T. Sformo, F. Olemaun, P. Anashugak, A. L. Von Duyke, R. Acker, B. T. Person, L. Sousa, L. Agnasagga, C. Sims Kayotuk, N. Kanayurak, C. George, and R. Suydam. 2022. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2021. International Whaling Commission, Scientific Committee, Document SC/68D/ASW/01.
- Scheimreif, K., R. Suydam, B. T. Person, R. Stimmelmayer, T. L. Sformo, A. L. Von Duyke, L. de Sousa, R. Acker, C. Sims Kayotuk, L. Agnasagga, M. Tuzroyluk, G. Sheffield, J. C. George, and A. Blair. 2021. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2020 and updates on genetics and health studies. International Whaling Commission, Scientific Committee, Document SC/68C/ASW/01.
- 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.
- Scholin, C. A., F. Gulland, G. J. Doucette, S. Benson, M. Busman, F. P. Chavez, J. Cordaro, R. DeLong, A. De Vogelaere, and J. Harvey. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. *Nature* 403(6765):80-84.
- 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, 16.
- 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.
- 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.
- Sheffield, G., and J. George. 2021. Diet and prey. Pages 429-455 in *The Bowhead Whale*. Elsevier.
- Sheffield, G., and L. Jemison. 2021. Community Report: Steller sea lion distribution and counts in the Bering Strait, March 3, 2021.

- Shelden, K. E., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. Norman, G. O'Corry-Crowe, D. Vos, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, February 2018. NOAA Technical Memorandum NMFS-AFSC-369, 227 p.
- 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. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, March 2015. AFSC Processed Report 2015-03, 55 p.
- Shelden, K. E. W., K. T. Goetz, A. A. Brower, A. L. Willoughby, and C. L. Sims. 2022. Distribution of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2021 and June 2022. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA, September 2022. AFSC Processed Report 2022-04, 80 p.
- 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. 2017a. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016. U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, June 2017. AFSC Processed Report 2017-09, 62 p.
- Shelden, K. E. W., R. C. Hobbs, C. L. Sims, L. Vate Brattstrom, J. A. Mocklin, C. Boyd, and B. A. Mahoney. 2017b. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016. NOAA National Marine Fisheries Service, Seattle, WA, 62.
- Shelden, K. E. W., T. R. Robeck, C. E. C. Goertz, T. L. McGuire, K. A. Burek-Huntington, D. J. Vos, and B. A. Mahoney. 2020. Breeding and calving seasonality in the endangered Cook Inlet beluga whale population: Application of captive fetal growth curves to fetuses and newborns in the wild. Marine Mammal Science 36(2):700-708.
- 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. U. S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, December 2013. NOAA Technical Memoorandum NMFS-AFSC-263, 131 p.

- 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. Alaska Department of Fish and Game, Divisions of Sport Fish and Commercial Fisheries, Fishery Management Report No. 17-05, Anchorage, AK, February 2017, 186 p.
- Sidorov, L. K., D. I. Litovka, and E. V. Vereshagin. 2021. Aboriginal subsistence whaling in the Russian Federation during 2020. International Whaling Commission, Scientific Committee, Document SC/68C/ASW/04.
- Sidorov, L. K., D. I. Litovka, and E. V. Vereshagin. 2022. Aboriginal subsistence whaling in the Russian Federation during 2021. International Whaling Commission, Scientific Committee, Document SC/68D/ASW/02.
- Sidorov, L. K., D. I. Litovka, and E. V. Vereshagin. 2023. Aboriginal subsistence whaling in the Russian Federation during 2022. International Whaling Commission, Scientific Committee, Document SC/69A/ASW/04.
- Sidorov, L. K., D. I. Litovka, and E. V. Vereshagin. 2024. Aboriginal subsistence whaling in the Russian Federation during 2023. International Whaling Commission, Scientific Committee, Document SC/69B/ASW/04.
- Sills, J. M., C. Reichmuth, B. L. Southall, A. Whiting, and J. Goodwin. 2020. Auditory biology of bearded seals (*Erignathus barbatus*). *Polar Biology* 43(11):1681-1691.
- Sills, J. M., B. L. Southall, and C. Reichmuth. 2015. Amphibious hearing in ringed seals (*Pusa hispida*): underwater audiograms, aerial audiograms and critical ratio measurements. *Journal of Experimental Biology* 218(Pt 14):2250-9.
- 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.
- Simmonds, M. P., and J. D. Hutchinson. 1996. The conservation of whales and dolphins - science and practice. John Wiley & Sons.
- 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.
- Sinclair, E., D. S. Johnson, T. K. Zeppelin, and T. S. Gelatt. 2013. Decadal variation in the diet of western stock Steller sea lions (*Eumetopias jubatus*). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration Center, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, April 2013. NOAA Technical Memorandum NMFS-AFSC-248.

- Sinclair, E. H., W. A. Walker, and P. J. Gearin. 2019. The diet of free-ranging male Steller sea lions (*Eumetopias jubatus*) in the eastern Bering Sea: a retrospective analysis based on stomach contents of an endangered pinniped. *Canadian Journal of Zoology* 97(3):195-202.
- 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. 2018a. 2018 Harvest Alaska Cook Inlet Pipeline Project Monitoring Program Marine Mammal Monitoring and Mitigation Report. Prepared by Fairweather Science for Harvest Alaska, LLC, Anchorage, AK, November 26, 2018.
- Sitkiewicz, S., W. Hetrick, K. Leonard, and S. Wisdom. 2018b. 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, November 26, 2018.
- SLR Consulting. 2017. Hilcorp Liberty Project Alaska Underwater and Airborne noise Modelling.
- Smiley, B. D., and A. R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards. Institute of Ocean Sciences, Sydney, Canada, 47 p.
- 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. Canadian Technical Report of Fisheries and Aquatic Sciences 1042:49 p.
- 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., M. O. Hammill, and G. Taugbøl. 1991. A review of the developmental, behavioural and physiological adaptations of the ringed seal, *Phoca hispida*, to life in the Arctic winter. *Arctic* 44(2):124-131.
- 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.
- Smith, T. G., and I. Stirling. 1978. Variation in the density of ringed seal (*Phoca hispida*) birth lairs in the Amundsen Gulf, Northwest Territories. *Canadian Journal of Zoology* 56(5):1066-1070.
- 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., 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.
- St. Aubin, D. J. 1990. Physiologic and toxic effects on pinnipeds. Pages 103-127 in J. R. a. S. A. Geraci, D. J., editor. *Sea mammals and oil, confronting the risks*. Academic Press, San Diego, California.
- Stafford, K. M. 2022. Singing behavior in the bowhead whale. Pages 277-295 in C. W. Clark, and E. C. Garland, editors. *Ethology and behavioral ecology of mysticetes*. Springer International Publishing, Cham, Switzerland.
- Stafford, K. M., and C. W. Clark. 2020. Acoustic behavior. Pages 323-338 in J. C. George, and J. G. M. Thewissen, editors. *The bowhead whale: Balaena mysticetus: Biology and human interactions*. Academic Press, San Diego, CA.
- Stafford, K. M., J. C. George, Q. Harcharek, and S. E. Moore. 2023. Humpback whale sightings in northern Arctic Alaska. *Marine Mammal Science* 40:246-253.

- Stafford, K. M., H. Melling, S. E. Moore, C. L. Berchok, E. K. Braen, A. M. Brewer, and B. M. Kimber. 2022. Marine mammal detections on the Chukchi Plateau 2009–2020. *The Journal of the Acoustical Society of America* 151(4):2521-2529.
- 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.
- Sternfeld, M. 2004a. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. USDOC, NOAA, NMFS Alaska Region, Juneau, Alaska, December 13, 2004, 3 p.
- Sternfeld, M. 2004b. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. NMFS, Alaska Region, Juneau, December 13, 2004, 3 p.
- Stimmelmayer, R., J. J. Citta, K. Scheimreiff, M. Ferguson, G. H. Givens, A. Willoughby, A. Brower, A. Von Duyke, G. Sheffield, B. Person, T. Sformo, L. de Sousa, and R. Suydam. 2022. 2020-2021 Health report for the Bering-Chukchi-Beaufort seas bowhead whale. International Whaling Commission, Scientific Committee, Document SC/68D/ASW/03.
- Stimmelmayer, R., J. J. Citta, K. Scheimreiff, G. H. Givens, A. Brower, K. M. Stafford, A. R. Szesciorka, A. L. Von Duyke, B. T. Person, T. L. Sformo, and L. De Sousa. 2024. 2022-2023 Health report for the Bering-Chukchi-Beaufort seas bowhead whales. International Whaling Commission, Scientific Committee, Document SC/69B/ASW/5.
- Stimpert, A. K., W. W. L. Au, S. E. Parks, T. Hurst, and D. N. Wiley. 2011. Common humpback whale (*Megaptera novaeangliae*) sound types for passive acoustic monitoring. *Journal of the Acoustical Society of America* 129(1):476-482.
- Stirling, I. 1983. The evolution of mating systems in pinnipeds. Pages 489-527 in J. F. Eisenberg, and D. G. Kleiman, editors. Recent advances in the study of mammalian behavior, Special Publication No. 7. American Society of Mammalogists.
- Stirling, I., and T. G. Smith. 2004. Implications of warm temperatures and an unusual rain event for the survival of ringed seals on the coast of southeastern Baffin Island. *Arctic* 57(1):59-67.
- Stoeger, A. S., D. Mitchen, 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 Mammalogy, Special Publication 2. Allen Press, Lawrence, Kansas.
- Straley, J. M., J. R. Moran, K. M. Boswell, J. J. Vollenweider, R. A. Heintz, T. J. Quinn II, B. H. Witteveen, and S. D. Rice. 2018. Seasonal presence and potential influence of humpback whales on wintering Pacific herring populations in the Gulf of Alaska. *Deep Sea Research Part II: Topical Studies in Oceanography* 147:173-186.
- Sullender, B. K., K. Kapsar, A. Poe, and M. Robards. 2021. Spatial Management Measures Alter Vessel Behavior in the Aleutian Archipelago. *Frontiers in Marine Science* 7:579905.

- Sullivan, R. M. 1980. Seasonal occurrence and haul-out use in pinnipeds along Humboldt County, California. *Journal of Mammalogy* 61(4):754-760.
- Suryan, R. M., M. L. Arimitsu, H. A. Coletti, R. R. Hopcroft, M. R. Lindeberg, S. J. Barbeaux, S. D. Batten, W. J. Burt, M. A. Bishop, J. L. Bodkin, R. Brenner, R. W. Campbell, D. A. Cushing, S. L. Danielson, M. W. Dorn, B. Drummond, D. Esler, T. Gelatt, D. H. Hanselman, S. A. Hatch, S. Haught, K. Holderied, K. Iken, D. B. Irons, A. B. Kettle, D. G. Kimmel, B. Konar, K. J. Kuletz, B. J. Laurel, J. M. Maniscalco, C. Matkin, C. A. E. McKinstry, D. H. Monson, J. R. Moran, D. Olsen, W. A. Palsson, W. S. Pegau, J. F. Piatt, L. A. Rogers, N. A. Rojek, A. Schaefer, I. B. Spies, J. M. Straley, S. L. Strom, K. L. Sweeney, M. Szymkowiak, B. P. Weitzman, E. M. Yasumiishi, and S. G. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports* 11(1):6235.
- Suydam, R., and J. C. George. 2020. Current indigenous whaling. Pages 519-535 in J. C. George, and J. G. M. Thewissen, editors. *The bowhead whale: *Balaena mysticetus*: Biology and human interactions*. Academic Press, San Diego, California.
- Suydam, R., J. C. George, B. Person, C. Hanns, and G. Sheffield. 2011a. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. International Whaling Commission, Scientific Committee, SC/63/BRG02.
- Suydam, R., J. C. George, B. Person, C. Hanns, and G. Sheffield. 2011b. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. International Whaling Commission-Scientific Committee, Tromso, Norway, 7.
- 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. International Whaling Commission, Scientific Committee, SC/64/BRG02.
- 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. International Whaling Commission, Scientific Committee, SC/65b/BRG08.
- Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayer, L. Pierce, and G. Sheffield. 2013a. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2012. International Whaling Commission, Scientific Committee, SC/65a/BRG19.
- Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayer, L. Pierce, and G. Sheffield. 2013b. 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. International Whaling Commission, Scientific Committee, SC/66a/BRG06.
- 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, Scientific Committee, SC/66b/BRG03.

- Suydam, R., J. C. George, B. Person, R. Stimmelmayer, T. Sformo, L. Pierce, A. Von Duyke, L. de Sousa, and G. Sheffield. 2018. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2017. International Whaling Commission, Scientific Committee, Document SC/67B/AWMP/05.
- Suydam, R., J. C. George, B. T. Person, D. Ramey, R. Stimmelmayer, T. L. Sformo, L. Pierce, and G. Sheffield. 2017. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2016. International Whaling Commission, Scientific Committee, Document SC/67a/AWMP/02 Rev1.
- Suydam, R., J. C. George, B. T. Person, R. Stimmelmayer, T. L. Sformo, L. Pierce, A. Von Duyke, L. de Sousa, R. Acker, and G. Sheffield. 2020. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2019. International Whaling Commission, Scientific Committee, Document SC/68B/ASW/01.
- Suydam, R., J. C. George, B. T. Person, R. Stimmelmayer, T. L. Sformo, L. Pierce, A. Von Duyke, L. de Sousa, R. Acker, G. Sheffield, and A. Baird. 2019. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2018. International Whaling Commission, Scientific Committee, Document SC/68A/AWS/02.
- Sweeney, A. J., Q. Fu, S. Po-Chedley, H. L. Wang, and M. Y. Wang. 2023. Internal variability increased Arctic amplification during 1980-2022. *Geophysical Research Letters* 50(24).
- Sweeney, K., R. Towell, and T. Gelatt. 2018. Results of Steller Sea Lion Surveys in Alaska, June-July 2018. U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA, December 2018.
- Sweeney, K. L., B. Birkemeier, K. Luxa, and T. Gelatt. 2025. Results of the Steller sea lion surveys in Alaska, June-July 2024. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, Alaska Ecosystem Program, Seattle, WA, February 2025. AFSC Processed Report 2025-02, 47 p.
- Szesciorka, A. R., and K. M. Stafford. 2023. Sea ice directs changes in bowhead whale phenology through the Bering Strait. *Movement Ecology* 11(1):1-13.
- 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.
- Terhaar, J., T. Tanhua, T. Stöven, J. C. Orr, and L. Bopp. 2020. Evaluation of data-based estimates of anthropogenic carbon in the Arctic Ocean. *Journal of Geophysical Research-Oceans* 125(6).
- 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. G. 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 H. R. McFarland, editors. 2024. *Alaska's changing environment 2.0*. University of Alaska Fairbanks, International Arctic Research Center, Alaska Center for Climate Assessment and Policy.
- 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., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. *Journal of the Acoustical Society of America* 80(3):735-740.
- 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., L. Fritz, R. Joy, K. Miller, A. Schulze, J. Thomason, W. Walker, T. Zeppelin, and T. Gelatt. 2017. Diet of endangered Steller sea lions (*Eumetopias jubatus*) in the Aleutian Islands: new insights from DNA detections and bioenergetic reconstructions. *Canadian Journal of Zoology* 95(11):853-868.
- 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.
- 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.
- Tsujii, K., M. Otsuki, T. Akamatsu, I. Matsuo, K. Amakasu, M. Kitamura, T. Kikuchi, K. Miyashita, and Y. Mitani. 2016. The migration of fin whales into the southern Chukchi Sea as monitored with passive acoustics. *ICES Journal of Marine Science* 73(8):2085-2092.

- 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.
- 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. 2019. A Ten-Year Projection of Maritime Activity in the U.S. Arctic Region, 2020–2030, Washington, D.C., 118 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. 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., January 4, 2019.
- 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* 65:273-283.
- 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* 68:89-96.
- 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.
- VanWormer, E., J. A. K. Mazet, A. Hall, V. A. Gill, P. L. Boveng, J. M. London, T. Gelatt, B. S. Fadely, M. E. Lander, J. Sterling, V. N. Burkanov, R. R. Ream, P. M. Brock, L. D. Rea, B. R. Smith, A. Jeffers, M. Henstock, M. J. Rehberg, K. A. Burek-Huntington, S. L. Cosby, J. A. Hammond, and T. Goldstein. 2019. Viral emergence in marine mammals in the North Pacific may be linked to Arctic sea ice reduction. *Scientific Reports* 9(1):15569.
- 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. Susitna Hydro Aquatic Studies Report.
- von Biela, V. R., L. Bowen, S. D. McCormick, M. P. Carey, D. S. Donnelly, S. Waters, A. M. Regish, S. M. Laske, R. J. Brown, and S. Larson. 2020. Evidence of prevalent heat stress in Yukon River Chinook salmon. *Canadian Journal of Fisheries and Aquatic Sciences* 77(12):1878-1892.
- Von Duyke, A. L., D. C. Douglas, J. K. Herreman, and J. A. Crawford. 2020. Ringed seal (*Pusa hispida*) seasonal movements, diving, and haul-out behavior in the Beaufort, Chukchi, and Bering Seas (2011–2017). *Ecology and evolution* 10(12):5595-5616.
- von Schuckmann, K., A. Minière, F. Gues, F. J. Cuesta-Valero, G. Kirchengast, S. Adusumilli, F. Straneo, M. Ablain, R. P. Allan, P. M. Barker, H. Beltrami, A. Blazquez, T. Boyer, L. J. Cheng, J. Church, D. Desbruyeres, H. Dolman, C. M. Domingues, A. García-García, D. Giglio, J. E. Gilson, M. Gorfer, L. Haimberger, M. Z. Hakuba, S. Hendricks, S. Hosoda, G. C. Johnson, R. Killick, B. King, N. Kolodziejczyk, A. Korosov, G. Krinner, M. Kuusela, F. W. Landerer, M. Langer, T. Lavergne, I. Lawrence, Y. H. Li, J. Lyman, F. Marti, B. Marzeion, M. Mayer, A. H. MacDougall, T. McDougall, D. P. Monselesan, J. Nitzbon, I. Otosaka, J. Peng, S. Purkey, D. Roemmich, K. Sato, K. Sato, A. Savita, A. Schweiger, A. Shepherd, S. I. Seneviratne, L. Simons, D. A. Slater, T. Slater, A. K. Steiner, T. Suga, T. Szekely, W. Thiery, M. L. Timmermans, I. Vanderkelen, S. E. Wjiffels, T. H. Wu, and M. Zemp. 2023. Heat stored in the earth system 1960-2020: Where does the energy go? *Earth System Science Data* 15(4):1675-1709.
- Vos, D. J., and K. E. W. Shelden. 2005. Unusual mortality in the depleted Cook Inlet beluga (*Delphinapterus leucas*) population. *Northwestern Naturalist* 86(2):59-65.
- Wade, P. R. 2021. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas.

- National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA. Paper submitted to the International Whaling Commission SC/68C/IA/03.
- 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. International Whaling Commission, 42 p.
- Walsh, J. E. 2008. Climate of the Arctic marine environment. *Ecological Applications* 18(2 Supplement):S3-S22.
- Ward, E. J., E. E. Holmes, and K. C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. *Journal of Applied Ecology* 46(3):632-640.
- 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.
- Wasser, S. K., J. I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons, and R. Booth. 2017. Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). *PLoS One* 12(6):e0179824.
- 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.
- Webster, M. A., I. G. Rigor, S. V. Nghiem, N. T. Kurtz, S. L. Farrell, D. K. Perovich, and M. Sturm. 2014. Interdecadal changes in snow depth on Arctic sea ice. *Journal of Geophysical Research: Oceans* 119(8):5395-5406.
- 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. 2007a. A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology* 20(2):159-168.

- Weilgart, L. S. 2007b. A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology* 20(2).
- Weir, C. R., and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). *Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom* 87(1):39-46.
- 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.
- Westley, P. A. 2020. Documentation of en route mortality of summer chum salmon in the Koyukuk River, Alaska and its potential linkage to the heatwave of 2019. *Ecology and Evolution* 10(19):10296-10304.
- Weston Solutions. 2022. Hilcorp Alaska Cook Inlet jack-up rig transportation activities - Marine mammal monitoring report, 18.
- Whitehead, H., and L. Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour* 118:275-296.
- 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.
- Wild, L. A., H. E. Riley, H. C. Pearson, C. M. Gabriele, J. L. Neilson, A. Szabo, J. Moran, J. M. Straley, and S. DeLand. 2023. Biologically Important Areas II for cetaceans within U.S. and adjacent waters—Gulf of Alaska region. *Frontiers in Marine Science* 10:763.
- Williams, M. T., C. S. Nations, T. G. Smith, V. D. Moulton, and C. J. J Perham. 2006. Ringed seal (*Phoca hispida*) use of subnivean structures in the Alaskan Beaufort Sea during development of an oil production facility. *Aquatic Mammals* 32(3):311-324.
- 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.
- Willoughby, A. L., M. C. Ferguson, R. Stimmelmayer, and A. A. Brower. 2022. Bowhead whale (*Balaena mysticetus*) carcasses documented during the 2019 aerial surveys in the eastern Chukchi and western Beaufort seas: a follow-up to evidence of bowhead whale and killer whale (*Orcinus orca*) co-occurrence during 2009–2018. *Polar Biology* 45(12):1723-1728.
- Willoughby, A. L., M. C. Ferguson, R. Stimmelmayer, J. T. Clarke, and A. A. Brower. 2020. Bowhead whale (*Balaena mysticetus*) and killer whale (*Orcinus orca*) co-occurrence in the U.S. Pacific Arctic, 2009–2018: evidence from bowhead whale carcasses. *Polar Biology* 43(11):1669-1679.

- Wilson, S. C., I. Crawford, I. Trukhanova, L. Dmitrieva, and S. J. Goodman. 2020. Estimating risk to ice-breeding pinnipeds from shipping in Arctic and sub-Arctic seas. *Marine Policy* 111:103694.
- Wilson, S. C., I. Trukhanova, L. Dmitrieva, E. Dolgova, I. Crawford, M. Baimukanov, T. Baimukanov, B. Ismagambetov, M. Pazylbekov, M. Jüssi, and S. J. Goodman. 2017. Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. *Biological Conservation* 214:213-222.
- Winn, H. E., P. J. Perkins, and T. C. Poulter. 1970. Sounds of the humpback whale. Pages 39-52 in 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park.
- Withrow, D. 1982. Using aerial surveys, ground truth methodology, and haul out behavior to census Steller sea lions, *Eumetopias jubatus*. University of Washington, Seattle, WA, 102 p.
- Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling. Pages 387-408 in J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The bowhead whale, Society for Marine Mammalogy Special Publication Number 2. Allen Press, Inc., Lawrence, KS.
- World Meteorological Organization. 2025. State of the global climate 2024. World Meteorological Organization, WMO-No. 1369, Geneva, Switzerland.
- Wright, S. 2016. 2016 Copper River Delta carcass surveys, annual report. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region Protected Resources Division, Juneau, AK.
- Wright, S. 2021. 2019 Copper River Delta carcass surveys, annual report. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region Protected Resources Division, Juneau, AK, May 3, 2021.
- 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.
- Würsig, 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.
- Yamamoto, A., M. Kawamiya, A. Ishida, Y. Yamanaka, and S. Watanabe. 2012. Impact of rapid sea-ice reduction in the Arctic Ocean on the rate of ocean acidification. *Biogeosciences* 9(6):2365-2375.
- York, A. E. 1994. The population dynamics of northern sea lions, 1975-1985. *Marine Mammal Science* 10(1):38-51.
- Young, B., and S. Ferguson. 2013. Seasons of the ringed seal: pelagic open-water hyperphagy, benthic feeding over winter and spring fasting during molt. *Wildlife Research* 40(1):52-60.
- Young, N. C., A. A. Brower, M. M. Muto, J. C. Freed, R. P. Angliss, N. A. Friday, B. D. Birkemeier, P. L. Boveng, B. M. Brost, M. F. Cameron, J. L. Crance, S. P. Dahle, B. S.

- Fadely, M. C. Ferguson, K. T. Goetz, J. M. London, E. M. Oleson, R. R. Ream, E. L. Richmond, K. E. W. Sheldon, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2024a. Alaska marine mammal stock assessments, 2023. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, December 2024. NOAA Technical Memorandum NMFS-AFSC-493, 327 p.
- Young, N. C., A. A. Brower, M. M. Muto, J. C. Freed, R. P. Angliss, N. A. Friday, B. D. Birkemeier, P. L. Boveng, B. M. Brost, M. F. Cameron, J. L. Crance, S. P. Dahle, B. S. Fadely, M. C. Ferguson, K. T. Goetz, J. M. London, E. M. Oleson, R. R. Ream, E. L. Richmond, K. E. W. Sheldon, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2024b. Alaska marine mammal stock assessments, 2023. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-493, December 2024, 327.
- Zarnke, R. L., J. T. Saliki, A. P. Macmillan, S. D. Brew, C. E. Dawson, J. M. Ver Hoef, K. J. Frost, and R. J. Small. 2006. Serologic survey for *Brucella* spp., phocid herpesvirus-1, phocid herpesvirus-2, and phocine distemper virus in harbor seals from Alaska, 1976-1999. *Journal of Wildlife Diseases* 42(2):290-300.
- 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.
- 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.
- Zharikov, K. A. 2018. Aboriginal subsistence whaling in the Russian Federation during 2017. International Whaling Commission, Scientific Committee, Document SC/67B/ASW/22.
- Zharikov, K. A., D. I. Litovka, and E. V. Vereshagin. 2019. Aboriginal subsistence whaling in the Russian Federation during 2018. International Whaling Commission, Scientific Committee, Document SC/68A/ASW/03.
- Zharikov, K. A., D. I. Litovka, and E. V. Vereshagin. 2020. Aboriginal subsistence whaling in the Russian Federation during 2019. International Whaling Commission, Scientific Committee, Document SC/68B/ASW/05.
- Zhou, W. Y., L. R. Leung, and J. Lu. 2024. Steady threefold Arctic amplification of externally forced warming masked by natural variability. *Nature Geoscience* 17(6).
- Zimmer, W. M. X., P. Tyack, M. Johnson, and P. T. Madsen. 2005. Three-dimensional beam pattern of regular sperm whale clicks confirms bent-horn hypothesis. *The Journal of the Acoustical Society of America* 117(3):1473-1485.