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Comprehensive Synthesis of Effects of Oil and Gas Activities on Marine Mammals on the Alaska Outer Continental Shelf

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Volume 1

U.S. Department of the Interior
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Volume 1

This report consists of two volumes: Volume 1 contains Chapters 1–6; Volume 2 contains Chapters 7–11.

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DISCLAIMER

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ABOUT THE COVER

The report cover consists of a collection of marine mammals in the U.S. Arctic and oil and gas activities in the Beaufort Sea, Alaska. Photo credits: Bowhead Whale Observed in Aerial Surveys of Arctic Marine Mammals, NOAA Fisheries (top left); Northstar Island in the Beaufort Sea, BOEM (top right); Ringed Seal Pup by M. Cameron, NOAA Fisheries (center); Polar Bear with Cubs, U.S. Fish and Wildlife Service (bottom right); and Seismic Vessel, BOEM (bottom left).

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List of Abbreviations and Acronyms

°	Degree
%	Percent
2D	Two-Dimensional
3D	Three-Dimensional
4C	Four-Component
ABWC	Alaska Beluga Whale Committee
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AIR	Aerial Infrared
AMAR	Autonomous Multichannel Acoustic Recorder
AMMDRG	Arctic Marine Mammal Disaster Response Guidelines
ANHSC	Alaska Native Harbor Seal Commission
AOGA	Alaska Oil and Gas Association
APDES	Alaska Pollutant Discharge Elimination System
ARRT	Alaska Regional Response Team
ASAMM	Aerial Surveys of Arctic Marine Mammals
ATBA	Areas to be Avoided
bbl	Barrels
BiOp	Biological Opinion
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BOP	blowout preventers
BPXA	BP Exploration (Alaska), Inc.
BSEE	Bureau of Safety and Environmental Enforcement
CAA	Conflict Avoidance Agreement
CatEx	Categorical Exclusion
CBS	Chukchi/Bering Seas Stock
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CI	Confidence Interval
CIPL	Hilcorp’s Cross Inlet Pipeline Project
CISPRI	Cook Inlet Spill Prevention & Response, Inc
CI/SS	Cook Inlet/Shelikof Strait
cm	centimeters
CPA	Closest Observed Point of Approach
cSEL	Cumulative Sound Exposure Level
CSESP	Chukchi Sea Environmental Studies Program
CTS	Compound Threshold Shift
CV	Coefficient of Variation
CWA	Clean Water Act
DASAR	Directional Autonomous Seafloor Acoustic Recorder
dB	Decibels
DMA	Dynamic Management Area
DPS	Distinct Population Segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ENP	Eastern North Pacific
ESA	Endangered Species Act

eshw	Effective Strip Half-Width
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
FR	Federal Register
GPS	Global Positioning System
ha	Hectare
Hz	Hertz
ICRW	International Convention for the Regulation of Whaling
IHA	Incidental Harassment Authorization
IMO	International Maritime Organization
in^3	Cubic Inch
Industry	Alaska's Oil and Gas Industry
ITA	Incidental Take Authorization
IWC	International Whaling Commission
kg	Kilograms
kHz	Kilohertz
km	Kilometer
km^2	Square Kilometers
kts	Knots
LCI	Lower Cook Inlet Seismic Survey
LOA	Letter of Authorization
LOC	Letter of Concurrence
m	Meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MHHW	Mean Higher High Water
MMC	Marine Mammal Commission
MML	Marine Mammal Laboratory
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
NEPA	National Environmental Policy Act
nm	Nautical Mile
NMFS	National Marine Fisheries Service
N_{min}	Minimum Population Estimate
NOA	NOAA Administration Order
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSB	North Slope Borough
NSR	Northern Sea Route
NWP	Northwest Passage
OBC	Ocean Bottom Cable
OBN	Ocean Bottom Node
OBS	Ocean Bottom Seismic
OCS	Outer Continental Shelf
OSRV	Oil Spill Response Vessel
OSV	Offshore Supply Vessel
OWD	Open Water Days
PAH	Polycyclic Aromatic Hydrocarbon
PAM	Passive Acoustic Monitoring
PBR	Potential Biological Removal
POC	Plan of Cooperation
POWER	Pacific Ocean Whale and Ecosystem Research
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
RL	Received Level

rms	root-mean-square
SARs	Stock Assessment Reports
SBF	Synthetic-Based Fluid
SBS	Southern Beaufort Sea
SEL	Sound Exposure Level
SICAA	Social Indicators in Coastal Alaska: Arctic Communities
SL	Source Level
SLR	SLR Consulting
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SSV	Sound Source Verification
TK	Traditional Knowledge
TS	Threshold Shift
TSS	Traffic Separation Scheme
TTS	Temporary Threshold Shift
μPa	microPascal
UAS	Uncrewed Aircraft System
UME	Unusual Mortality Event
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protect Agency
USFWS	United States Fish and Wildlife Service
U.S.C.	United States Code
USCG	United States Coast Guard
USDOI	United States Department of Interior
VSP	Vertical Seismic Profiling
VTOL	Vertical Takeoff and Landing
WBF	Water-Based Fluid
WCA	Whaling Convention Act

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1. Introduction

1.1. Purpose

The purpose of this synthesis is to provide an enhanced understanding of the potential direct, indirect, and cumulative effects of oil and gas resource development on marine mammals in the Arctic and Cook Inlet within the context of other human activities and natural factors in these areas for the period 2000 – 2020. For the purposes of this synthesis, the United States (U.S.) Arctic is defined as the Alaskan Beaufort and Chukchi seas.

The U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM) must comply with numerous environmental statutes, regulations, and executive orders to carry out its mission including but not limited to the National Environmental Policy Act (NEPA), Marine Mammal Protection Act (MMPA), and Endangered Species Act (ESA). Compliance with these statutes requires evaluating and disclosing potential effects of oil and gas on marine mammals. Preparing a meaningful synthesis is not just compiling a list of summary findings from various sources but requires an understanding of the underlying science and relevant context. To that end, this synthesis is intended to summarize in a single document more than 20 years of available literature, reports, and information into concise statements that reflect the findings of representative literature on this topic in order for BOEM analysts to prepare future analyses. A retrospective summary of mitigation and monitoring measures that have been implemented between 2000 and 2020 to avoid or minimize adverse impacts to marine mammals is included and to the extent practical, an evaluation of the efficacy of these measures. Finally, this meta-analysis also reveals specific information needs related to the impacts of oil and gas activities on marine mammals in the U.S. Arctic and Cook Inlet.

1.2. Objectives

BOEM requires ready access to information that can be used in future NEPA and other analyses. In conducting this review, the following objectives are met:

- Synthesize information about the direct, indirect, and cumulative impacts of oil and gas resource development in the U.S. Arctic and Cook Inlet on marine mammals;
- Present findings within the context of other anthropogenic and natural factors;
- Compile a list of mitigation and monitoring measures and, to the extent possible, evaluate their efficacy; and
- Summarize and incorporate traditional knowledge regarding potential effects of oil and gas activities and the associated mitigation and monitoring measures that have been implemented.

1.3. Scope

This comprehensive synthesis specifically focuses on the potential direct, indirect, and cumulative effects of oil and gas activities on marine mammals in Cook Inlet and the Alaskan Beaufort and Chukchi seas for the period 2000 – 2020. Where appropriate, references to information from other regions or on other biological or natural resources such as fish, birds, or terrestrial species, are provided by way of reference. In addition, references to older studies prior to 2000 have been included on some topics, where appropriate.

While this synthesis does not encompass every article or report written on the topics of interest for this time period, it is intended to represent information most relevant to oil and gas activities and marine mammal species found in Cook Inlet, the Chukchi Sea, and the Beaufort Sea.

The marine mammal species under National Marine Fisheries Service's (NMFS) jurisdiction that may occur in the Beaufort and Chukchi seas include whale and seal species listed in Table 1-1. One whale species, the bowhead (*Balaena mysticetus*), is listed as endangered under the ESA. The bowhead whale and the Beaufort Sea stock of beluga whales (*Delphinapterus leucas*) are the most commonly occurring cetaceans in the Beaufort Sea. Individuals from the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) have been observed in the central and eastern Beaufort Sea but are not very common. Narwhals (*Monodon monoceras*) and harbor porpoise (*Phocoena phocoena*) are considered extralimital in the Beaufort Sea. Polar bears and Pacific walrus are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) and occur in the Chukchi and Beaufort seas, although Pacific walrus are very infrequent in the Beaufort Sea.

Marine mammal species known to occur in the Cook Inlet region are listed in Table 1-1. The majority of these species have geographic ranges that do not extend north of the Forelands and into Upper Cook Inlet. Only three species are common in Upper Cook Inlet: beluga whales (*Delphinapterus leucas*), harbor seals (*Phoca vitulina*), and harbor porpoises (*Phocoena phocoena*). Killer whales (*Orcinus orca*) and Steller sea lions (*Eumetopiaa jubatus*) occur more frequently in Lower Cook Inlet but may still be encountered in the upper inlet. Humpback whales (*Megaptera novaenagliae*) are infrequent to rare in Upper Cook Inlet and observed more frequently near the mouth of Lower Cook Inlet. Other species that have been observed in Lower Cook Inlet include the minke whale (*Balaenoptera acutorostrata*), fin whale (*B. physalus*), and gray whale (*Eschrichtius robustus*). Generally, fin whales and gray whales migrate past Cook Inlet, although small numbers have been noted near Kachemak Bay, and north of Anchor Point (BOEM 2016).

Table 1-1 provides the list of marine mammal species discussed in this report and the subject regions where they may occur based on the information sources reviewed. For species that are considered extralimital or for which little to no information exists, this is summarized in the report.

This synthesis is not intended to be an all-encompassing synthesis of relevant climate change literature but provides an overview of the "key themes" about climate change and associated impacts on marine mammals and their habitats within the context of the project objectives described above. The effects of climate-related stressors on marine mammals are specifically discussed in Section 10.2.

Table 1-1. Marine Mammal Species that May Occur in the Beaufort and Chukchi Seas and Cook Inlet (including Extralimital Species)

Common Name	Scientific Name	Stock or Distinct Population Segment (DPS)	Habitat	Current Subsistence Species in Region? Y/N	Occurrence in Region	ESA Status of Stock or DPS
Beaufort and Chukchi Seas						
Cetaceans						
Bowhead Whale	*Balaena mysticetus*	Western Arctic stock	Pack ice, open-water coastal and offshore	Y	Likely	E
Gray Whale	*Eschrichtius robustus*	Eastern North Pacific stock	Coastal, lagoons	N	Likely	NL
Minke Whale	*Balaenoptera acutorostrata scammoni*	North Pacific subspecies	Open-water coastal and offshore	N	Likely - Chukchi	NL
Humpback Whale	*Megaptera novaeangliae*	Western North Pacific DPS	Open-water coastal and offshore	N	Infrequent (Chukchi)	E
Fin Whale	*Balaenoptera physalus*	Northeast Pacific stock	Open-water	N	Infrequent (Chukchi)	E
Beluga Whale	*Delphinapterus leucas*	Beaufort Sea and Eastern Chukchi Sea stocks	Offshore, ice edge, coastal, lagoons	Y	Likely	NL
Killer Whale	*Orcinus orca*	Eastern North Pacific transient stock	Open water coastal and offshore	N	Likely	NL
Narwhal	*Monodon monoceros*	N/A	Pack ice, open-water coastal and offshore	N	Rare/extralimital	NL
Harbor Porpoise	*Phocoena*	Bering Sea stock	Coastal waters	Y	Rare/extralimital	NL
Pinnipeds						
Ringed Seal	*Phoca hispida*	Alaska stock	Landfast (but not bottom fast) and pack ice, open-water	Y	Likely	T
Bearded Seal	*Erignathus barbatus nauticus*	Beringia DPS	Pack ice, open-water	Y	Likely	T
Spotted Seal	*Phoca largha*	Alaska stock	Pack ice, open-water, coastal haulouts	Y	Likely	NL
Ribbon Seal	*Histriophoca fasciata*	Alaska stock	Pack ice, open-water	Y	Infrequent	NL
Pacific Walrus	*Odobenus rosmarus*	Alaska stock	Pack ice, open-water; coastal haulouts	Y	Likely – Chukchi Infrequent – Beaufort	NL

Common Name	Scientific Name	Stock or Distinct Population Segment (DPS)	Habitat	Current Subsistence Species in Region? Y/N	Occurrence in Region	ESA Status of Stock or DPS
Ursid						
Polar Bear	*Ursus maritimus*	Chukchi and Southern Beaufort Sea stocks	Landfast and pace ice, open-water; dens on land	Y	Likely	T
Cook Inlet						
Cetaceans						
Gray Whale	*Eschrichtius robustus*	Eastern North Pacific stock	Open water coastal and offshore	N	Infrequent (Southern Cook Inlet)	NL
Minke Whale	*Balaenoptera acutorostrata*	Alaska stock	Open water coastal and offshore	N	Infrequent	NL
Humpback Whale	*Megaptera novaeangliae*	Western North Pacific DPS	Open water coastal and offshore	N	Infrequent	E
Fin Whale	*Balaenoptera physalus*	Northeastern Pacific stock	Open water coastal and offshore	N	Infrequent (Southern Cook Inlet)	E
Beluga Whale	*Delphinapterus leucas*	Cook Inlet DPS	Open water coastal and offshore	N	Likely	E
Killer Whale	*Orcinus orca*	Alaska resident stock; Eastern North Pacific transient stock	Open water coastal and offshore	N	Infrequent	NL
Dall's Porpoise	*Phocoenoides dalli*	Alaska stock	Open water coastal and offshore	N	Infrequent	NL
Killer Whale	*Orcinus orca*	Alaska resident stock; Eastern North Pacific transient stock	Open water coastal and offshore	N	Infrequent	NL
Dall's Porpoise	*Phocoenoides dalli*	Alaska stock	Open water coastal and offshore	NY	Infrequent Likely	NL NL
Harbor Porpoise	*Phocoena*	Gulf of Alaska stock	Coastal waters and bays	Y	Likely	NL
Pinnipeds						
Harbor Seal	*Phoca vitulina*	Cook Inlet/Shelikof Stock	Coastal waters and bays, coastal haulouts	Y	Likely	NL

Common Name	Scientific Name	Stock or Distinct Population Segment (DPS)	Habitat	Current Subsistence Species in Region? Y/N	Occurrence in Region	ESA Status of Stock or DPS
Steller Sea Lion	*Eumetopias jubatus*	Western DPS	Coastal waters and bays, coastal haulouts	Y	Infrequent (Southern Cook Inlet)	E
California Sea Lion	*Zalophus californianus*	U.S. population	Coastal waters and bays, coastal haulouts	N	Rare/extralimital	NL
Mustelid						
Northern Sea Otter	*Enhydra lutris kenoyoni*	Southwest Alaska DPS	Coastal waters and bays	Y	Likely (Southern Cook Inlet)	T
Marine Transit Route						
Cetaceans						
N. Pacific Right Whale	*Eubalaena japonica*	Eastern North Pacific stock	Open water coastal and offshore	N	Rare	E
Fin Whale	*Balaenoptera physalus*	Northeast Pacific stock	Open water coastal and offshore	N	Uncommon	E
Blue Whale	*Balaenoptera musculus*	Eastern North Pacific stock	Open water coastal and offshore	N	Rare	E
Humpback Whale	*Megaptera novaeangliae*	Western North Pacific and Mexico DPSs	Open water coastal and offshore	N	Uncommon	E
Sperm Whale	*Physeter macrocephalus*	North Pacific stock	Open water coastal and offshore	N	Rare	E
Pinnipeds						
Steller Sea Lion	*Eumetopias jubatus*	Western DPS	Coastal waters and bays, coastal haulouts	N	Infrequent	E

Sources: https://www.adfg.alaska.gov/index.cfm?adfg=animals.main, https://www.fisheries.noaa.gov/species/, https://iwc.int/alaska, https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock; USFWS (2016b), MacCracken *et al.* (2017), USFWS (2017a), BOEM (2018), United States Court of Appeals (2018), NMFS (2019c, 2019a, 2019e), NMFS (2020e, 2020a, 2020b)
NL – Not Listed
E – Endangered
T – Threatened

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2. Methods – Literature Review and Synthesis

2.1. Identification and Screening of Literature and Information Sources

Key sources of information were identified from peer reviewed articles, scientific publications, technical reports produced by federal agencies, state agencies, industry, and other stakeholders, applications for rulemaking along with proposed or final rules published in the *Federal Register*, and public comments. Of particular focus were documents produced by the Alaska regional offices of BOEM, USFWS, and NMFS Alaska Region as well as NMFS Office of Protected Resources in Silver Spring, Maryland as part of regulatory analyses, compliance, and reporting required by statutes including the MMPA, ESA, and NEPA. Each information source was screened for key terms primarily including marine mammal species, oil and gas activities, and the geographic areas of interest (*i.e.*, Cook Inlet and Beaufort and Chukchi seas). Out of nearly 1,000 scientific, government, and industry reports, journal articles, and publications screened with regard to BOEM's objective, more than 600 were identified as germane to the topic of oil and gas activities and marine mammals in the regions of interest. Study selection bias was minimized by having multiple analysts assess the relevance and quality of literature.

Relevant information sources were entered into EndNote© (Version 20), a searchable citation database designed primarily for managing bibliographies, citations, and references. EndNote provides pre-defined fields for recording basic reference information including reference type (journal or report), year, author(s), title, institution, and document or identification number. Any of these fields can be searched using EndNote. Annotations in EndNote are listed in the "notes" data field. PDF documents for each information source is attached to the citation in the EndNote database. This allows users to open the PDF of the complete document directly from EndNote, if needed. In some cases, there may be multiple PDF attachments to a single citation (*i.e.*, a proposed rule and a final rule). Information sources were then categorized into eight topic "bins" as described below and shown in Figure 2-1.

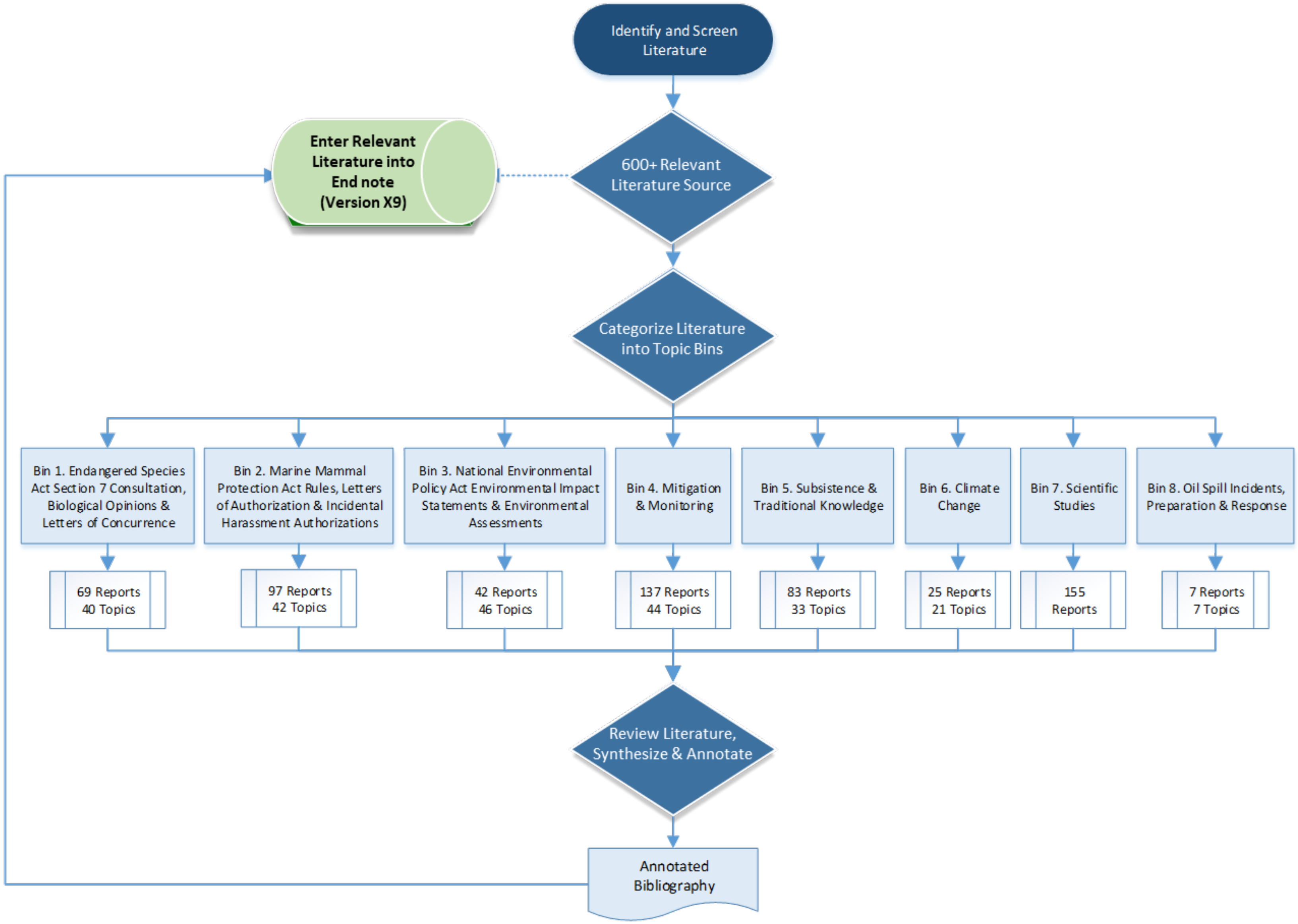

Figure 2-1. Literature Review and Annotation Process

2.2. Data Binning

Eight broad topic bins were established based on the categories outlined below. To help users cross-reference citation topics and allow for easy identification of specific issues of interest, checklists have been created for each bin and are included as Appendix A. In addition, Figures 2-2 through 2-9 provide a visual reference of the checklists to show the number of documents on specific topics in each bin, and the data from each figure is combined in Table 2-1 for easy comparison. Note that some citations cover more than one topic. This qualitative representation is intended to provide a general perspective on the amount of information available to natural resource managers, industry, scientists, and other stakeholders to evaluate other similar activities and inform decisions. The topic bins were based on the following categories.

Bin 1. Endangered Species Act Section 7 Consultation, Biological Opinions, and Letters of Concurrence

The ESA is the federal statute designed to protect endangered and threatened fish, wildlife, and plant species and their ecosystems upon which they depend. The ESA prohibits the "take" of species listed as endangered by the USFWS or NMFS. Once listed, Section 9 (16 U.S. Code [U.S.C.] § 1538) of the ESA makes it unlawful for any person to take individuals of an endangered species and by regulations at 16 U.S.C. § 1538(a), except as specified under provisions for exemption (16 U.S.C. §§ 1535(g)(2) and 1539). Under the ESA, to "take" a listed species means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" (16 U.S.C. § 1532(19)).

Section 7 (16 U.S.C. § 1536) requires that all federal agencies:

> *…shall, in consultation with, and with the assistance of the Secretary of the Interior or Commerce (Secretary), ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species, which is determined by the Secretary to be critical.*

Bin 1 includes Biological Opinions (BiOps) and other ESA Section 7 documents such, as Letters of Concurrence (LOCs) that were the result of a Section 7(a) consultation during the period 2000 – 2020. This bin contains 72 annotated citations, covering 40 topics (Figure 2-2 and Table 2-1).

Bin 2. Marine Mammal Protection Act Rules, Letters of Authorization, and Incidental Harassment Authorizations

Under the MMPA (16 U.S.C. § 1371, 50 Code of Federal Regulations [CFR] Subpart 1), the "taking" of marine mammals, incidental or otherwise, without a permit or exemption is prohibited. Take under the MMPA is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. § 1362). An exception to the MMPA moratorium on marine mammal takes is for the incidental, but not intentional, "taking" by U.S. citizens, as stated in Section 101(a)(5). An incidental take is an "unintentional, but not unexpected, take" of a marine mammal. Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. § 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings have been made and either regulations have been issued or, if the taking is limited to harassment, a notice of a proposed incidental take authorization may have been provided to the public for review. Authorization for incidental takings shall be granted if NMFS or USFWS find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses (where relevant).

Bin 2 includes MMPA rules, Letters of Authorization (LOAs) and Incidental Harassment Authorizations (IHAs), and related documents. This bin has 107 citations covering 42 topics (Figure 2-3 and Table 2-1).

Bin 3. National Environmental Policy Act Environmental Impact Statements and Environmental Assessment

NEPA established a nationwide policy for environmental protection and provides legal authority for federal agencies to carry out that policy (40 CFR § 1500.1(a)). It requires federal agencies to study and consider the environmental consequences of their actions prior to making decisions, which includes the consideration of environmental amenities and values (42 U.S.C. § 4332(B)). The NEPA process must be completed before an agency makes a final decision on a proposed action. The broad range of actions covered by NEPA may include making decisions on permit applications, adopting federal land management actions, or constructing facilities.

Unless it can be demonstrated that a proposed action will have no effect, or in some manner can be excluded from further environmental impact review, the agency must conduct an evaluation. These evaluations are referred to as Categorical Exclusions (CatEx), Environmental Assessments (EA), or Environmental Impact Statements (EIS). EAs are often accompanied by a Finding of No Significant Impact (FONSI), unless the findings indicate a more comprehensive review is required in an EIS.

Bin 3 includes NEPA documents prepared to evaluate proposed oil and gas activities that occurred or were planned for the period 2000 – 2020. Some of the projects annotated in Bin 3 may have subsequently been canceled or delayed after the NEPA process was complete. Bin 3 includes 49 annotated citations covering 46 topics (Figure 2-4 and Table 2-1).

Bin 4. Mitigation and Monitoring

The MMPA requires that effects are mitigated to the level of effecting "the least practicable adverse impact upon the affected species or stocks, their habitat, and their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance", regardless of extent or intensity of take. That is, applicants must employ mitigation measures when effective measures are available. Mitigation and monitoring required under the MMPA or ESA for oil and gas activities are documented in the form of Marine Mammal Monitoring Plans, 90-day Monitoring Reports, Annual Monitoring Reports, and Comprehensive Monitoring Reports (*i.e.*, that report for multiple years). In addition, published literature may report results of mitigation and monitoring efforts associated with oil and gas activities. These types of information sources comprise Bin 4 and by nature, relate to the authorizations and evaluations that comprise Bins 1-3. Bin 4 has 164 annotated reports covering 45 topics (Figure 2-5 and Table 2-1).

Bin 5. Subsistence and Traditional Knowledge

Federal agencies are encouraged to incorporate local and traditional knowledge (TK) into their decision-making processes. Sometimes also called traditional ecological knowledge or indigenous knowledge, BOEM refers to a body of evolving practical knowledge based on observations and personal experience of local residents over an extensive, multi-generational time period (BOEM 2012b). It includes first-hand knowledge gained from observations over a lifetime or as information passed down through generations by oral tradition. Incorporating local and TK into planning and permitting is important to ensure decisions are made with the best information available. TK has helped inform decision-makers regarding potential impacts to subsistence species and users that may result from oil and gas activities in the U.S. Arctic.

Bin 5 includes information sources on subsistence and TK as it relates to impacts from oil and gas activities and marine mammals. Bin 5 also contains annotations for mutually developed agreements such as Conflict Avoidance Agreements (CAA) or Plans of Cooperation (POC) that are developed between Alaska Native subsistence communities and industry to minimize the potential impacts of oil and gas on subsistence activities. In addition, a representative sample of public comments received from Alaska Native communities and organizations on federal processes, such as NEPA documents and MMPA authorizations, are also summarized. There are 106 annotated documents in this bin that cover 47 topics (Figure 2-6 and Table 2-1).

Bin 6. Climate Change

It is generally accepted in the scientific community that the global climate is changing (*i.e.*, on average planetary temperatures are warming, while aquatic environments are becoming more acidic). It has also been recognized that the impacts of climate change are being observed earlier in the Arctic, and with more immediate and severe consequences, than in other parts of the world. "Climate change brings about effects that extend outside the realm of natural variability with respect to both temporal (*e.g.,* seasonal, annual, decadal) and spatial (*e.g.,* local, regional, pan-Arctic) scales" (Niemi *et al.* 2019). Oil and gas activities in the U.S. Arctic have occurred during this warming trend. Therefore, it is important to place any potential effects of oil and gas activities on marine mammals in context of these dynamic changes.

Bin 6 includes information sources on climate change as relevant to the project objective on the potential impacts of oil and gas activities on marine mammals in the Beaufort and Chukchi seas and Cook Inlet. The impacts of climate change on marine mammals provides critical context for understanding the environmental baseline inhabited by marine mammals. Due to the sheer volume of articles on this subject, a relatively small sample of applicable literature has been included. There are 36 articles or reports annotated in this bin and they cover 21 topics (Figure 2-7 and Table 2-1).

Bin 7. Scientific Studies

Bin 7 includes peer-reviewed literature, journal articles, and other synthesis documents, such as the Synthesis of Arctic Research, among others, as they specifically relate to understanding the potential impacts of oil and gas activities on marine mammals in the Beaufort and Chukchi seas and Cook Inlet. Again, due to the large volume of scientific literature on the topic of oil and gas impacts, there is a large representative selection of literature on this and other relevant topics. Bin 7 includes 241 annotated citations covering 40 topics (Figure 2-8 and Table 2-1).

Bin 8. Oil Spill Incidents, Preparation, and Response

Bin 8 contains 16 documents regarding oil spill response guidelines, spill occurrence estimators, and preparedness. The documents cover 7 topics (Figure 2-9).

Checklists for each bin are included as Appendix A as a cross-reference. In addition, Figures 2 – 9 provide a visual reference of the checklists to show the number of documents on specific topics in each bin. This qualitative representation is intended to provide a general perspective on the amount of information available to natural resource managers, industry, scientists, and other stakeholders to evaluate other similar activities and inform decisions.

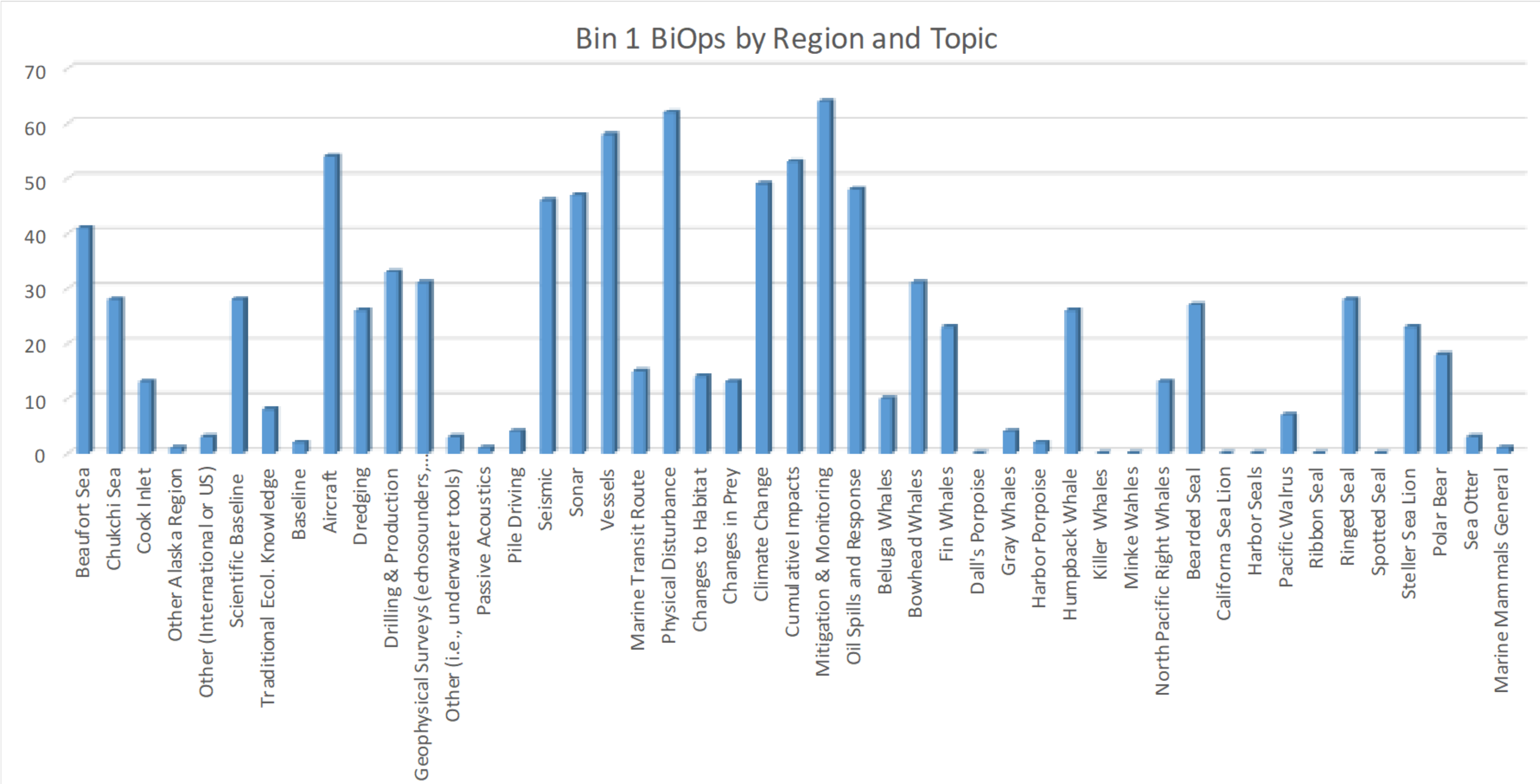

Figure 2-2. Bin 1: BiOps by Region and Topic

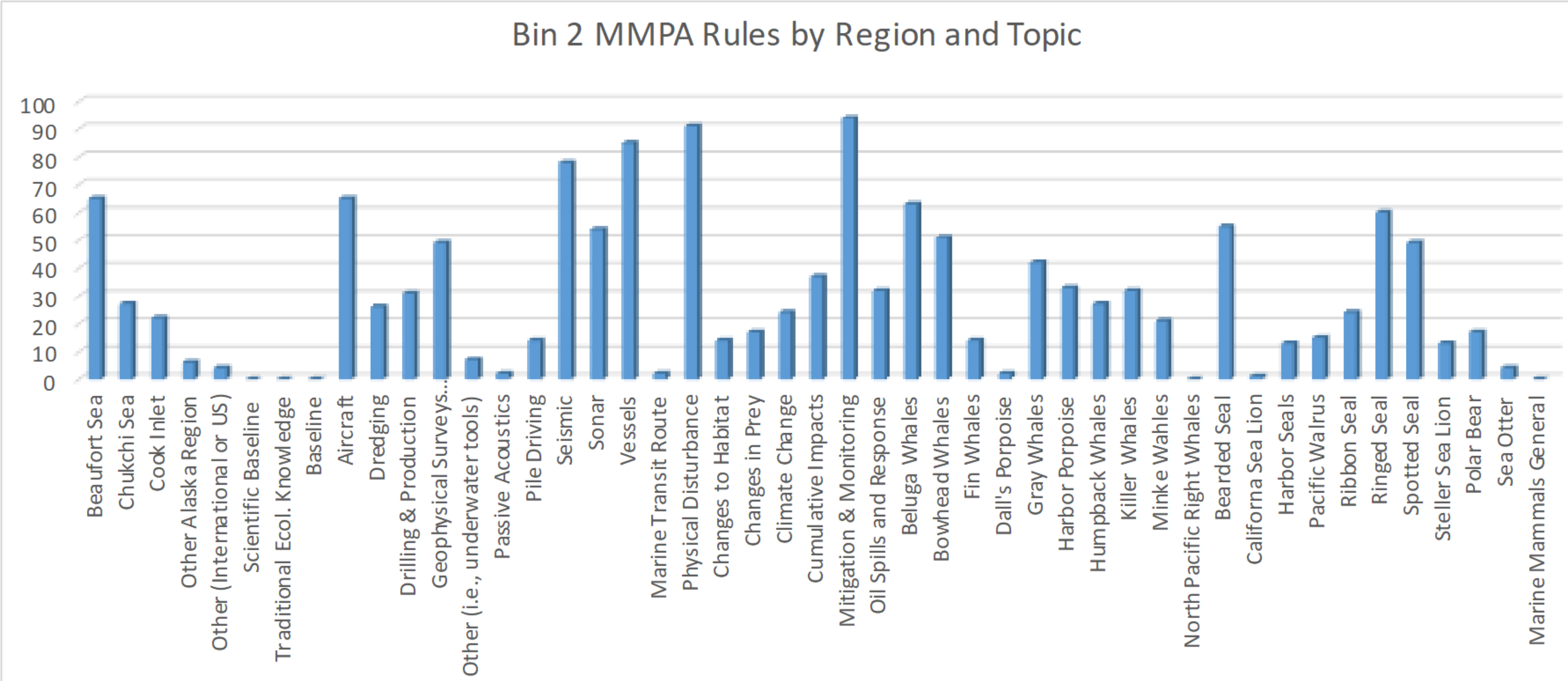

Figure 2-3. Bin 2: MMPA Rules by Region and Topic

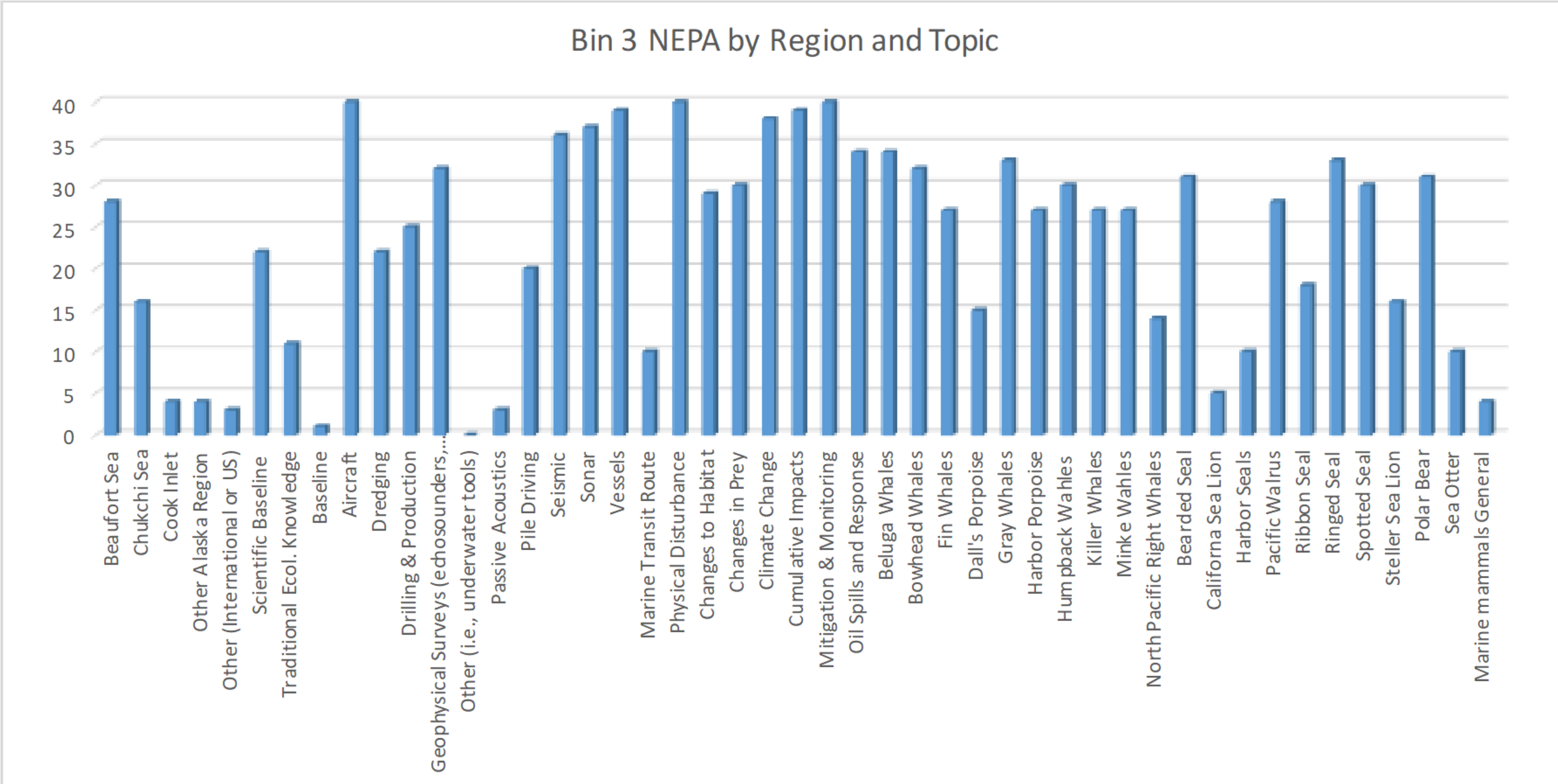

Figure 2-4. Bin 3: NEPA Analyses by Region and Topic

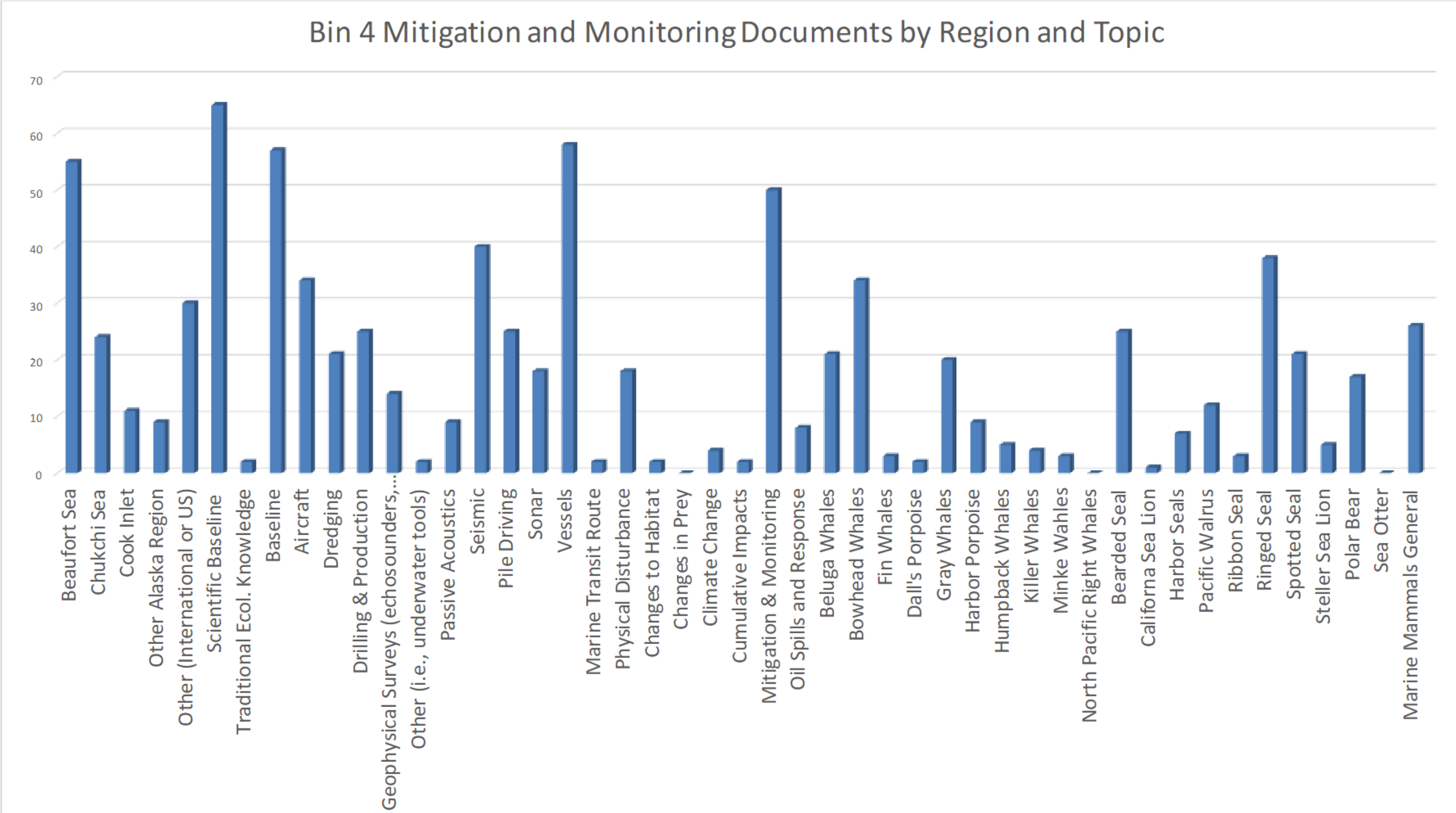

Figure 2-5. Bin 4: Mitigation and Monitoring Documents by Region and Topic

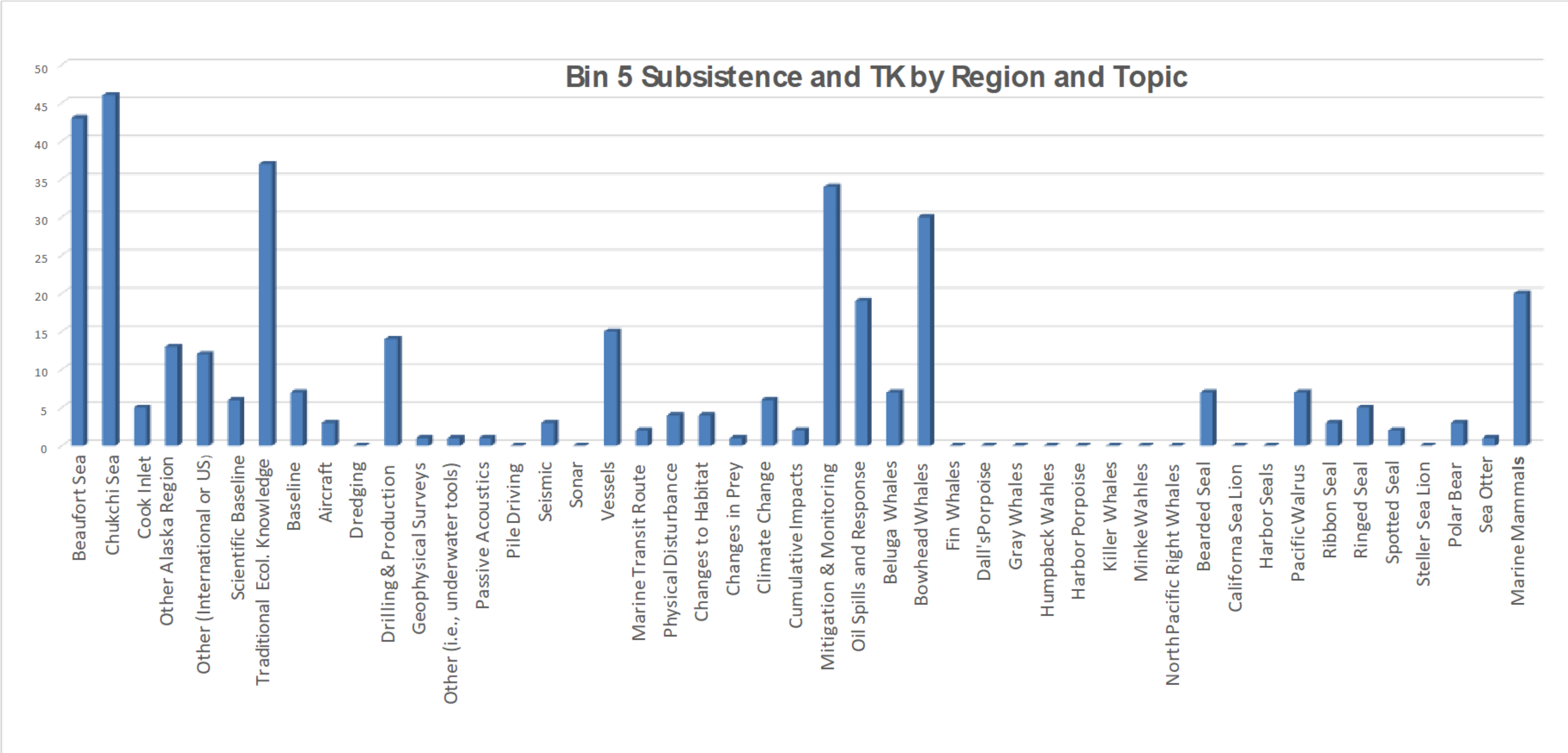

Figure 2-6. Bin 5: Subsistence and TK by Region and Topic

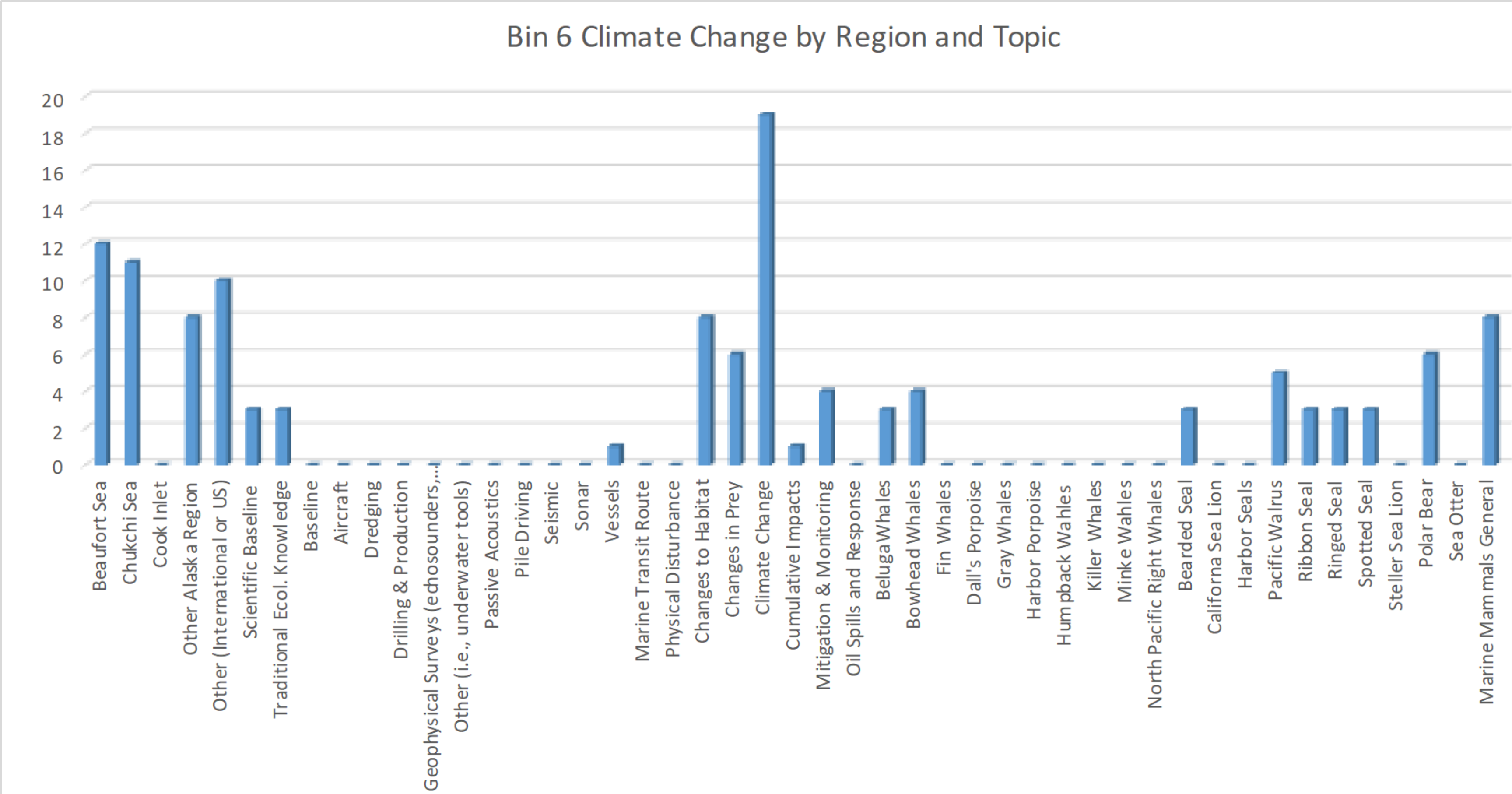

Figure 2-7. Bin 6: Climate Change by Region and Topic

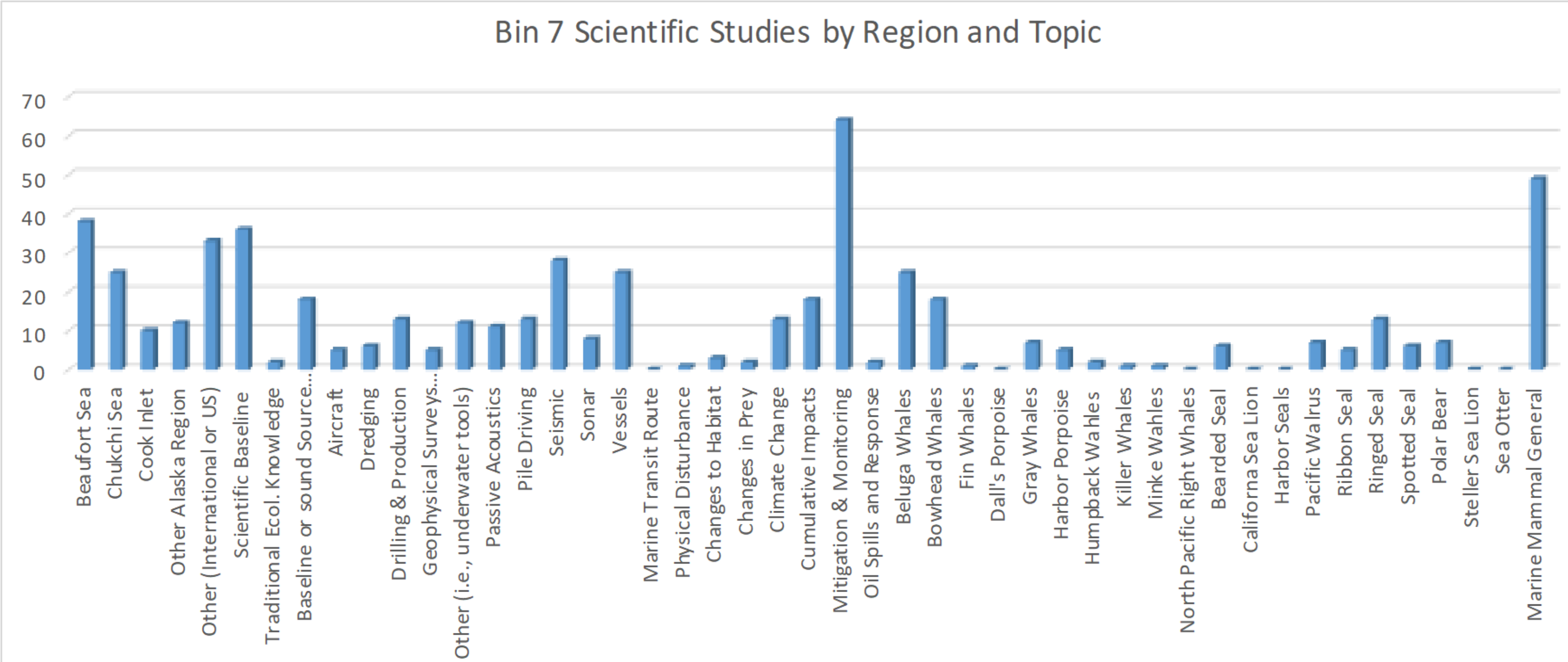

Figure 2-8. Bin 7: Scientific Studies by Region and Topic

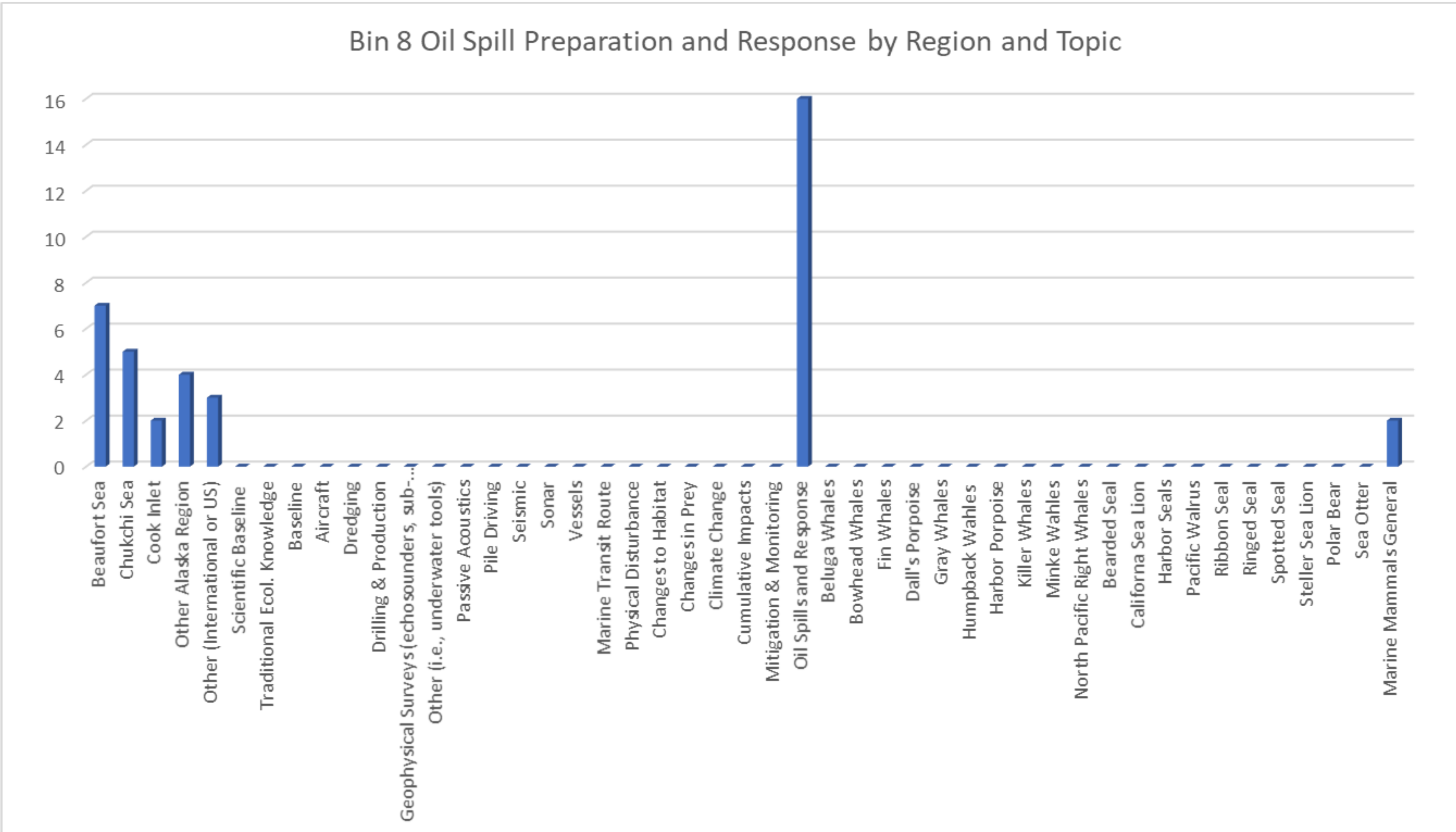

Figure 2-9. Bin 8: Oil Spill Preparation and Response by Region and Topic

Table 2-1. Numbers of Documents on Specific Topics in Each Bin

Regions/Topics	Bin 1 BiOps	Bin 2 MMPA Rules	Bin 3 NEPA	Bin 4 Mitigation and Monitoring	Bin 5 Subsistence and TK	Bin 6 Climate Change	Bin 7 Scientific Studies	Bin 8 Oil Spill Prep. and Resp.
Beaufort Sea	40	64	28	56	43	12	38	9
Chukchi Sea	28	26	15	24	45	11	24	6
Cook Inlet	12	21	4	10	5	0	9	4
Other Alaska Region	1	5	4	9	13	8	1	2
Other (International or U.S.)	3	3	3	30	12	10	32	1
Scientific Baseline	28	0	22	65	7	3	35	0
Traditional Ecol. Knowledge	7	0	11	2	37	3	2	0
Baseline	2	0	1	57	8	0	18	0
Aircraft	54	64	40	34	4	0	4	0
Dredging	25	28	22	20	1	0	5	0
Drilling & Production	32	30	24	24	13	0	12	0
Geophysical Surveys (echosounders…)	30	58	31	13	2	0	4	0
Other (underwater tools)	3	6	0	2	2	0	11	0
Passive Acoustics	1	2	3	8	2	0	10	0
Pile Driving	4	77	20	39	1	0	12	0
Seismic	45	84	36	25	4	0	28	0
Sonar	46	53	37	18	1	0	7	0
Vessels	58	85	38	58	15	1	25	0
Marine Transit Route	15	2	10	2	3	0	0	0
Physical Disturbance	61	90	40	18	4	0	1	0
Changes to Habitat	13	13	28	2	4	8	3	0
Changes in Prey	12	16	30	1	2	6	2	0
Climate Change	48	23	37	4	6	19	12	0
Cumulative Impacts	52	36	38	3	3	1	17	0
Mitigation & Monitoring	64	92	39	50	3	4	63	0
Oil Spills & Response	47	30	34	7	19	0	2	6
Beluga Whales	9	62	34	20	7	3	25	0
Bowhead Whales	30	50	32	34	32	4	17	0
Fin Whales	23	13	27	3	1	0	1	0
Dall’s Porpoise	0	2	15	2	1	0	0	0
Gray Whales	3	40	33	20	1	0	6	0
Harbor Porpoise	2	32	27	8	1	0	5	0
Humpback Whale	26	27	30	5	1	0	2	0

Regions/Topics	Bin 1 BiOps	Bin 2 MMPA Rules	Bin 3 NEPA	Bin 4 Mitigation and Monitoring	Bin 5 Subsistence and TK	Bin 6 Climate Change	Bin 7 Scientific Studies	Bin 8 Oil Spill Prep. and Resp.
Killer Whales	0	30	27	4	1	0	1	0
Minke Whales	0	19	27	3	1	0	1	0
North Pacific Right Whales	12	0	13	0	1	0	0	0
Bearded Seal	27	54	30	24	7	3	6	0
California Sea Lion	0	1	5	1	1	0	0	0
Harbor Seals	0	11	19	7	1	0	0	0
Pacific Walrus	7	13	28	11	7	5	6	0
Ribbon Seal	0	23	18	3	4	3	5	0
Ringed Seal	28	59	32	38	5	3	12	0
Spotted Seal	0	48	30	20	3	3	5	0
Stellar Sea Lion	22	12	16	5	1	0	0	0
Polar Bear	18	15	30	17	4	6	6	0
Sea Otter	3	3	10	0	2	0	0	0
Marine Mammals General	2	0	4	27	20	8	48	1

2.3. Annotated Bibliography

As a quick reference to analysts, an annotated bibliography was created from the 500+ information sources in the EndNote database. Each annotation includes a brief (150 – 250 words) descriptive and evaluative paragraph intended to inform readers of the relevance, major themes, and topics covered, and key findings. Due to the broad scope of information sources (*i.e.*, ranging from peer reviewed articles to technical reports to applications for rulemaking), annotations may contain different types of information and read differently.

In some cases, information sources may relate to each other, such as a proposed and final rule or a series of monitoring reports such as a 90-Day, Annual, and Comprehensive Marine Mammal Monitoring Reports, as required under the MMPA. In such cases, there may be one annotation to represent the series of documents referenced. Annotations were organized by the eight broad category bins described above and presented chronologically within each bin.

Output from the annotated bibliography helped structure this synthesis by identifying key themes, information needs, and opportunities for future research that may address policy and management of oil and gas or marine mammals. The complete annotated bibliography is included as Appendix B.

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3. Description of Oil and Gas Activities

3.1. History of Oil and Gas Activities in Arctic and Cook Inlet 2000–2020

This chapter provides an overview of major oil and gas exploration and development projects in Alaska's Beaufort and Chukchi seas and Cook Inlet, including State of Alaska waters. The first Outer Continental Shelf (OCS) lease sale in Alaska concerned the Gulf of Alaska, Lease Sale 39, in 1976 (Braund and Kruse 2009). Figure 3-1 presents the number of wells drilled in the Alaska OCS from 1979 – 2019.

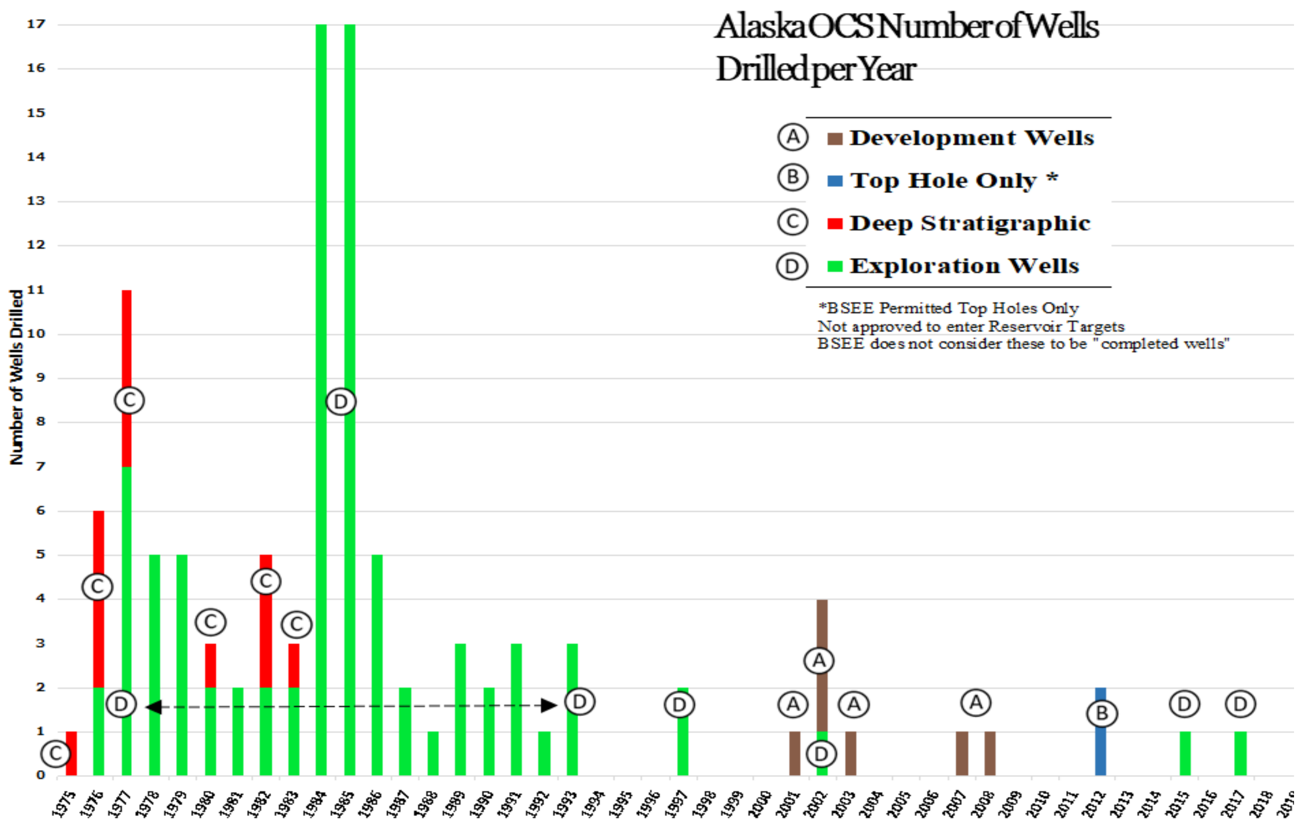

Figure 3-1. History of Wells Drilled in the Alaska OCS

Source: https://www.boem.gov/Alaska-Historical-Data; (Accessed May 25, 2021)

Figures 3-2 and 3-3 list major oil and gas projects dating back to 1957 for the Beaufort and Chukchi seas and Cook Inlet, respectively. The scope of this report focuses on the period covering 2000–2020; the list of projects in Figures 3-2 and 3-3 are intended to demonstrate the location, scope, and number of activities that have occurred over the past 20–50 years.

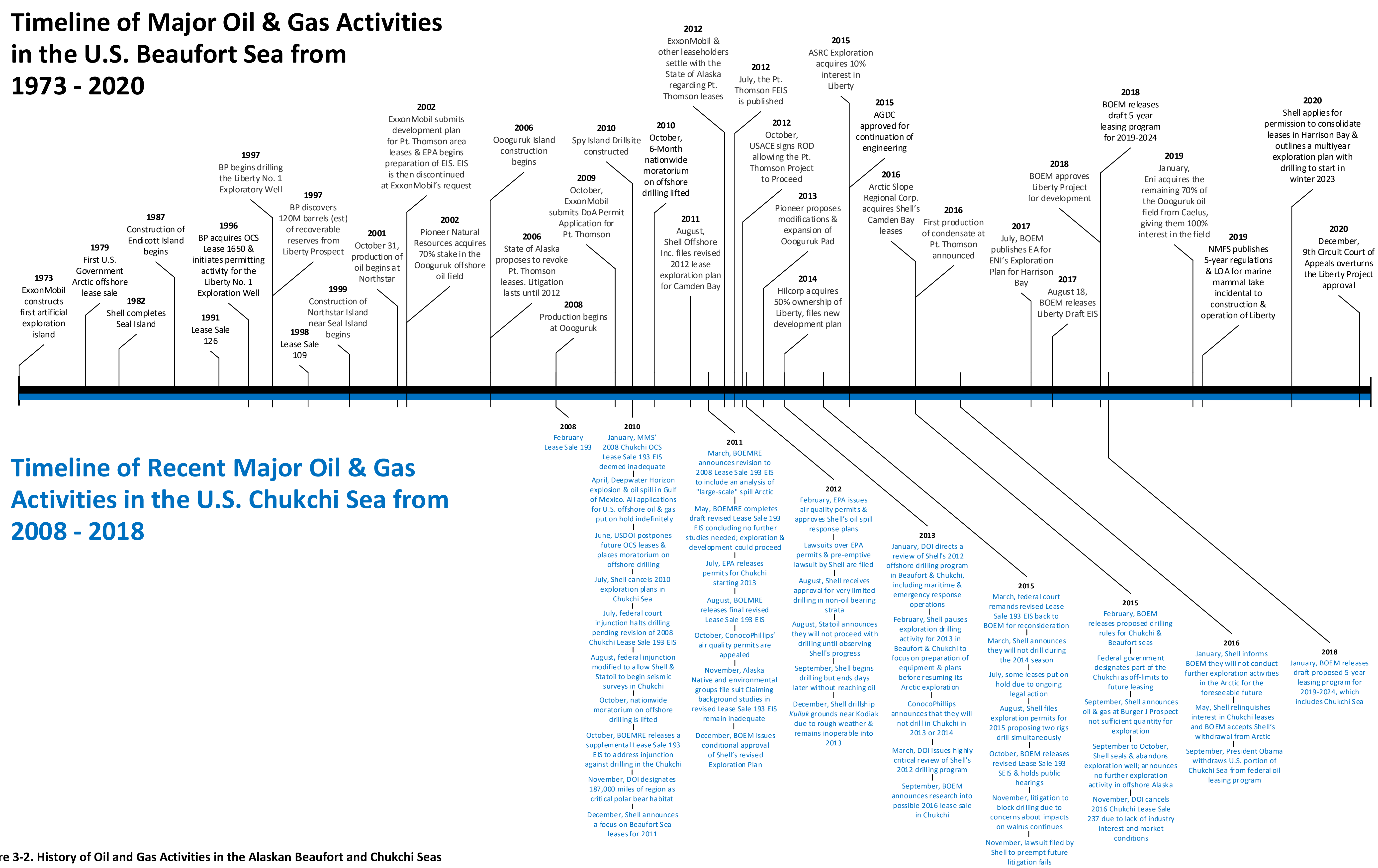

Figure 3-2. History of Oil and Gas Activities in the Alaskan Beaufort and Chukchi Seas

Timeline of Major Oil & Gas Activities in Cook Inlet, Alaska from 1957 - 2019

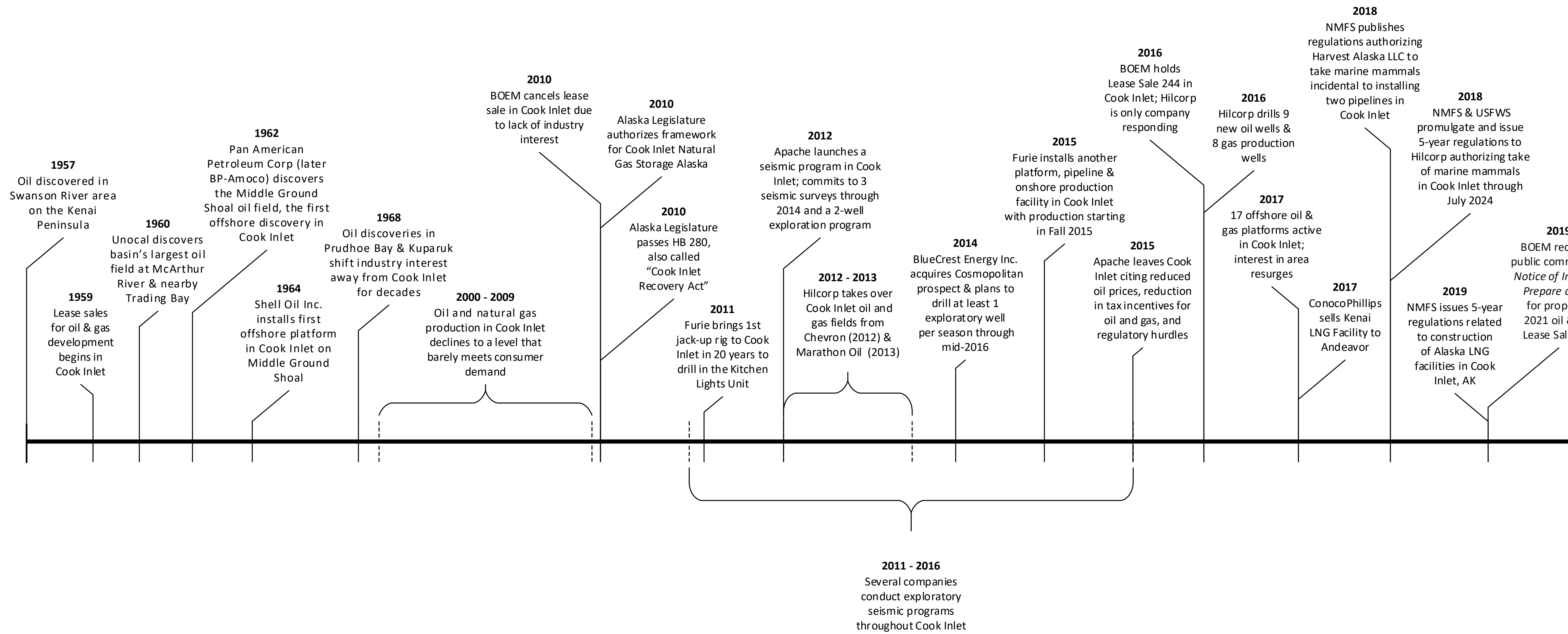

Figure 3-3. History of Oil and Gas Activities in Cook Inlet, Alaska

3.1.1. Beaufort Sea

Oil and gas development on the Alaska North Slope began as a single oil field at Prudhoe Bay and has grown into an industrial complex of developed oil fields, and their associated interconnecting roads, pipelines, and power lines that stretch from the Point Thomson development in the east to the Alpine field past the Colville River on the west. Figure 3-4 shows North Slope oil and gas development activities from 1968 to 2003. Following the discovery of the Prudhoe Bay oil field inland in 1967, the first offshore oil and gas lease sale for the Beaufort Sea occurred in 1979. Eleven OCS exploration wells were determined to be capable of production, and five of these have been termed important discoveries (Banet Jr. 1991). Four were in OCS waters (*i.e.*, Kuvlum, Hammerhead, Sandpiper, and Tern/Liberty). The fifth is the Northstar field, which straddles the state/federal boundary and extends into both state and OCS waters. Northstar has been developed and began production in 2001. As of 2019, there have been a total of 39 wells drilled in the Beaufort Sea OCS, including exploratory, deep stratigraphic test, and development wells, and top holes.[1] As of 2020, oil and gas is produced at Northstar, Nikaitchuq Spy Island, Oooguruk Drill Site, and Duck Island Units: Endicott MPI, Endicott SDI, and Endeavor. Except for Northstar, these units lie in state waters.

The National OCS Oil and Gas Leasing Program[2] establishes a schedule of oil and gas lease sales in federal waters. The size, timing, and location of potential leasing activity as determined by the Secretary of the Interior to meet national energy needs are specified. The most recent federal OCS Beaufort Sea Lease Sale was held in April of 2007 (Lease Sale 202). Bids on 90 tracts were accepted (Figure 3-5). Beaufort Sea Lease Sale 242 that had been scheduled for 2017 was canceled, and a lease sale originally proposed for 2019 also did not occur. Current Beaufort Sea federal lease owners are shown in Figure 3-6. As of January 2022, there are 18 active federal leases in the Beaufort Sea.

The State of Alaska also conducts areawide lease sales for tracts on state land or in state waters.[3] The first competitive oil and gas lease sale for state waters in the Beaufort Sea was held in 1979.[4] The most recent state lease sale was conducted in 2021. Three bids covering about 3,000 hectares (ha) onshore at Prudhoe Bay were accepted from one bidder.[5] Although available, no bids were received for offshore tracts (Figure 3-7).

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[1] https://www.boem.gov/Alaska-Historical-Data; (Accessed May 25, 2021)

[2] https://www.boem.gov/national-ocs-oil-and-gas-leasing-program; (Accessed August 16, 2021)

[3] https://dog.dnr.alaska.gov/Services/BIFAndLeaseSale; (Accessed August 16, 2021)

[4] https://dog.dnr.alaska.gov/documents/leasing/saleresults/summary_of_all_lease_sale_results.pdf; (Accessed August 16, 2021)

[5] https://dog.dnr.alaska.gov/documents/leasing/saleresults/beaufortsea/2021W/BSA2021W_preliminary_summary.pdf ; (Accessed August 16, 2021)

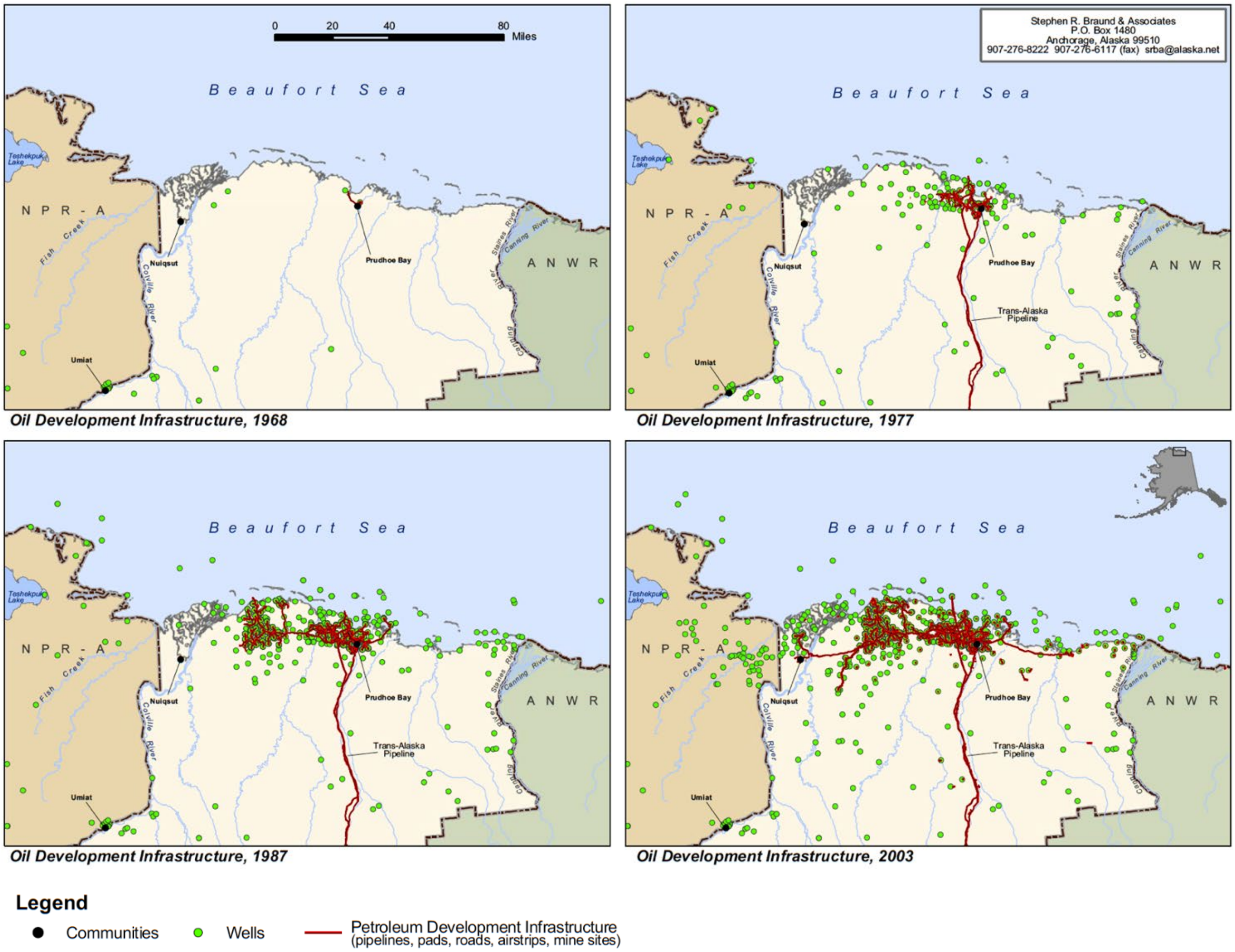

Figure 3-4. Petroleum Development Activities on the Alaska North Slope 1968–2003

Source: Stephen R. Braund & Associates (2009)

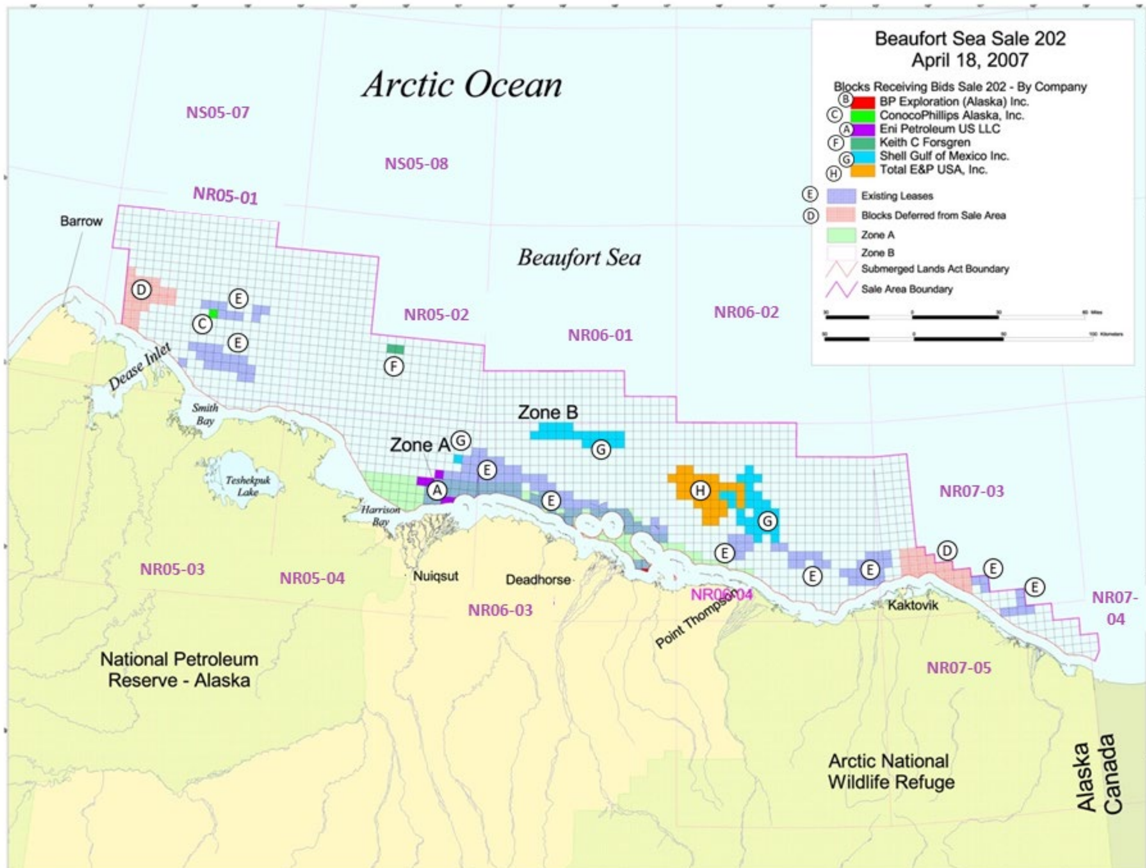

Figure 3-5. BOEM Lease Sale 202 Results

Source:
https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/Leasing/Regional_Leasing/Alaska_Region/Alaska_Lease_Sales/Sale_202/sale_202_final_by_co_april07.pdf; (Accessed August 16, 2021)

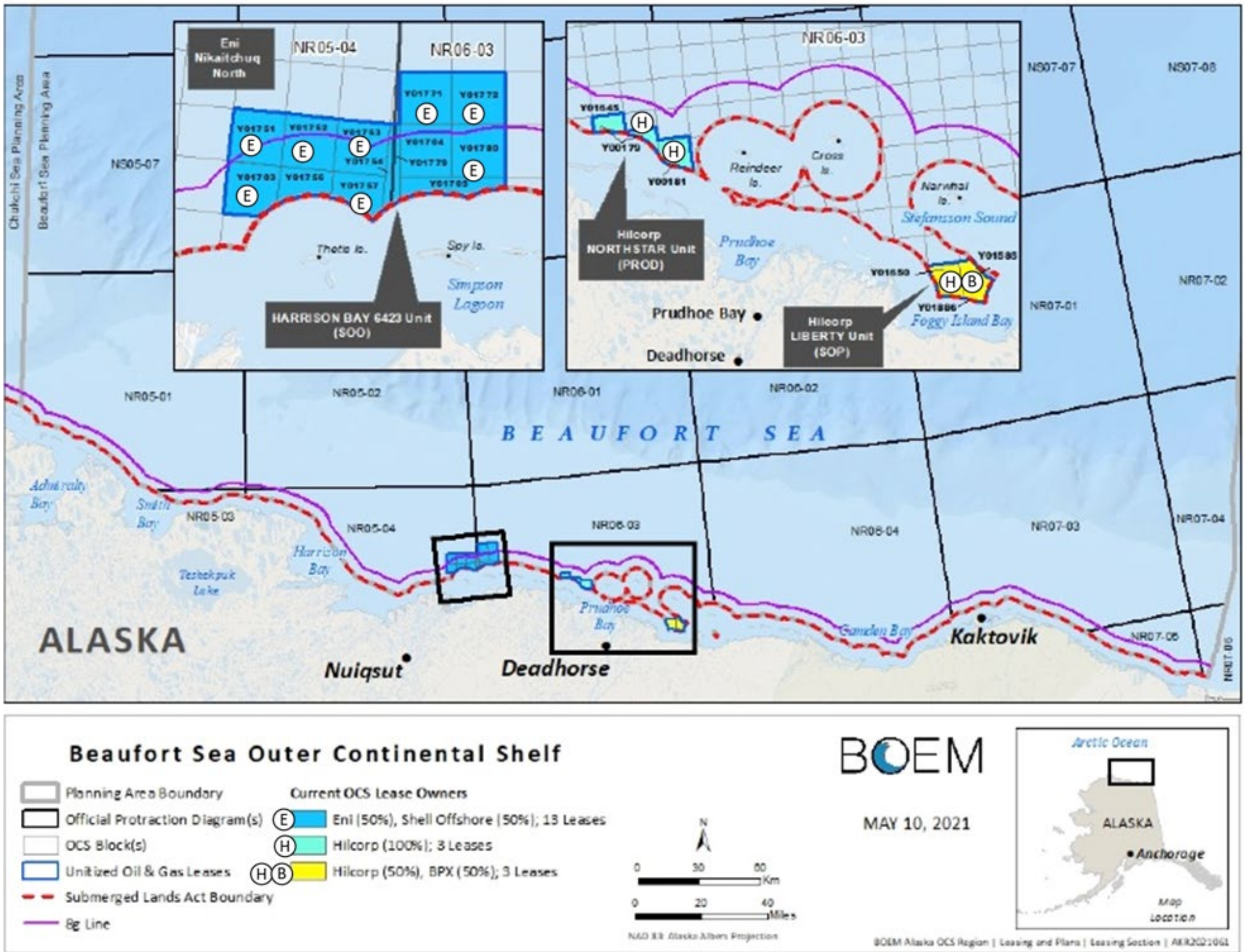

Figure 3-6. Current Beaufort Sea Oil and Gas Lease Owners

Source: https://www.boem.gov/sites/default/files/documents/environment/AKR2021061-ActiveLease-BFT%20SEA.pdf (Accessed February 16, 2022)

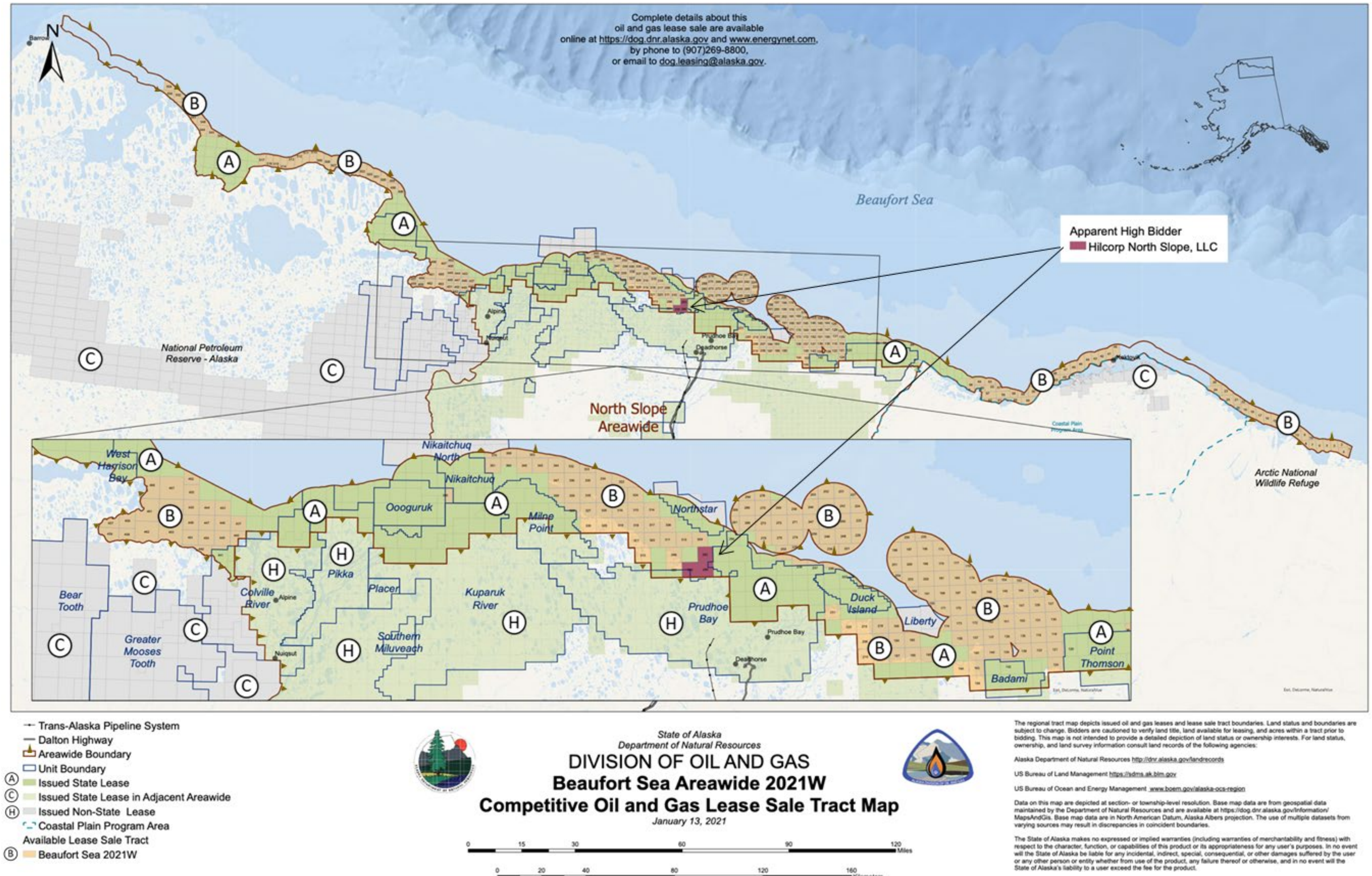

Figure 3-7. State of Alaska Areawide Lease Sale Results 2021W

Source: https://dog.dnr.alaska.gov/Documents/Leasing/SaleResults/BeaufortSea/2021W/BSA2021W_Results_Map.pdf; (Accessed August 16, 2021)

3.1.2. Chukchi Sea

The first well drilled in the Chukchi Sea occurred in 1989. During the period 2007 – 2012, one lease sale was held by the Minerals Management Service (MMS) (now BOEM) in February 2008 (Lease Sale 193) resulting in 487 leases and bids worth $2.7 billion. As of 2019, however, only seven wells have been drilled in the Chukchi Sea despite the area having an estimated 18% of the total U.S. offshore oil and gas reserves.[6] Currently, all Chukchi Sea leases have been relinquished and there are no active federal leases in the Chukchi Sea.

The most recent federal OCS lease sale in the Chukchi Planning Area was held in February of 2008 (Lease Sale 193). Six hundred sixty-seven bids were received on 488 blocks, with the closest block about 90 kilometers (km) offshore.[7] The sale was challenged in the U.S. District Court of the District of Alaska, and additional environmental analysis was completed (BOEM 2015a). Two lease sales were held prior to the 193 sale: Sale 109 was held in 1988 with 351 leases issued and Sale 126 in 1991 with 28 leases issued. Chukchi Sea lease sale 237 that had been scheduled to occur in 2016 was canceled by BOEM.[8] There have been no State of Alaska lease sales in Chukchi Sea waters. Figure 3-8 shows the historical exploratory drill sites in the Chukchi Sea beginning in 1989.

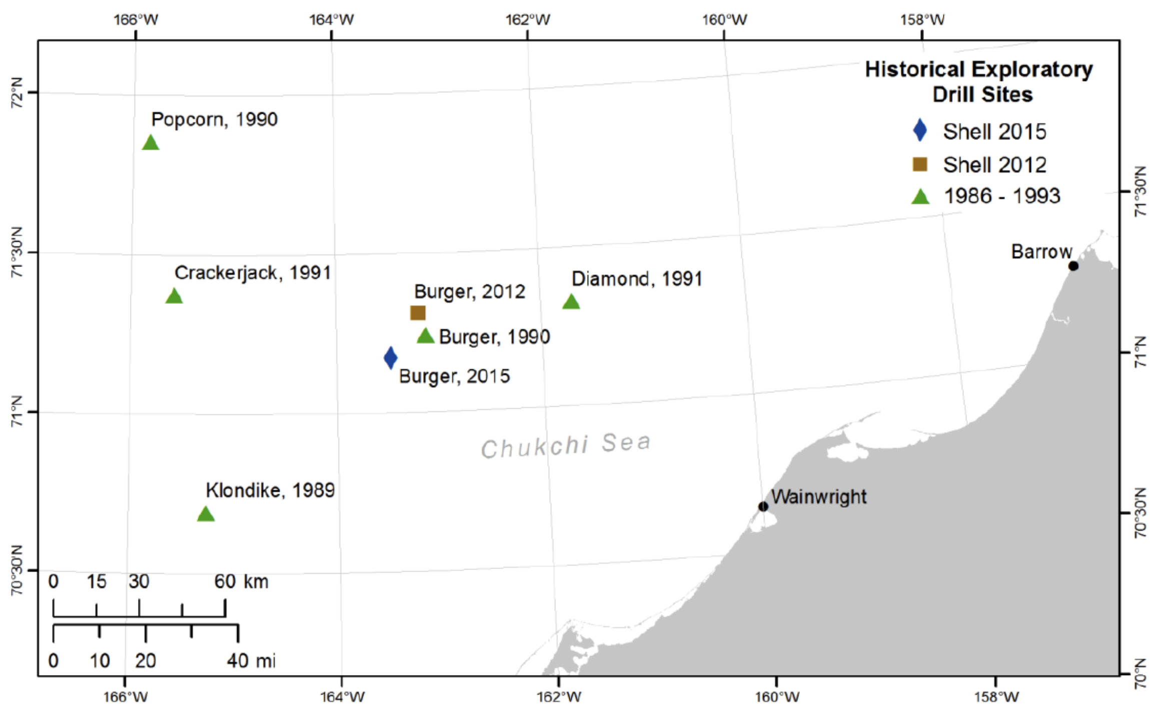

Figure 3-8. Offshore Exploratory Drill Sites in the Alaskan Chukchi Sea 1989 – 2015.

Source: Ireland *et al.* (2016)

[6] https://www.boem.gov/Alaska-Historical-Data; (Accessed May 25, 2021)

[7] https://www.boem.gov/sites/default/files/boem-newsroom/Press-Releases/2008/press0206.pdf; (Accessed August 16, 2021)

[8] https://www.boem.gov/about-boem/chukchi-sea-oil-and-gas-lease-sale-237-canceled; (Accessed August 16, 2021)

3.1.3. Cook Inlet

Figure 3-9 shows the working interest ownership of oil and gas units in Cook Inlet, Alaska as of 2021. By the late 1960s, 14 offshore oil production facilities were installed in the State of Alaska waters of Upper Cook Inlet, indicating that most of the Cook Inlet platforms and much of the associated infrastructure, is more than 40 years old (NMFS 2017b). Today, there are 17 platforms in the State of Alaska waters of Cook Inlet, the majority of which are operated by Hilcorp Alaska, LLC (Figure 3-9).

State of Alaska lease sales for oil and gas development in Cook Inlet began in 1959 and have occurred annually since that time with the exception of a few years.[9] Prior to the lease sales, there were attempts at oil exploration along the west side of Cook Inlet (ADNR 2017). The most recent state of Alaska Areawide lease sale in Cook Inlet occurred in spring of 2020; about 2,900 ha in three Lower Cook Inlet tracts were leased. Figure 3-10 shows the location of these tracts and all State of Alaska tracts in Cook Inlet.

Federal lease sales have also occurred in Cook Inlet OCS waters since 1977.[10] The most recent Cook Inlet OCS lease sale occurred in 2017 (Lease Sale 244). Figure 3-11 shows the OCS blocks that received bids during that sale. Cook Inlet Lease Sale 258, covering the blocks shown in Figure 3-12 is planned for June of 2022. Figure 3-13 shows the current active federal leases and state/federal boundaries of the Cook Inlet Planning Area.

[9] https://dog.dnr.alaska.gov/Documents/Leasing/SaleResults/Summary_of_All_Lease_Sale_Results.pdf; (Accessed August 16, 2021)

[10] https://www.boem.gov/about-boem/historical-alaska-bid-recaps; (Accessed August 16, 2021)

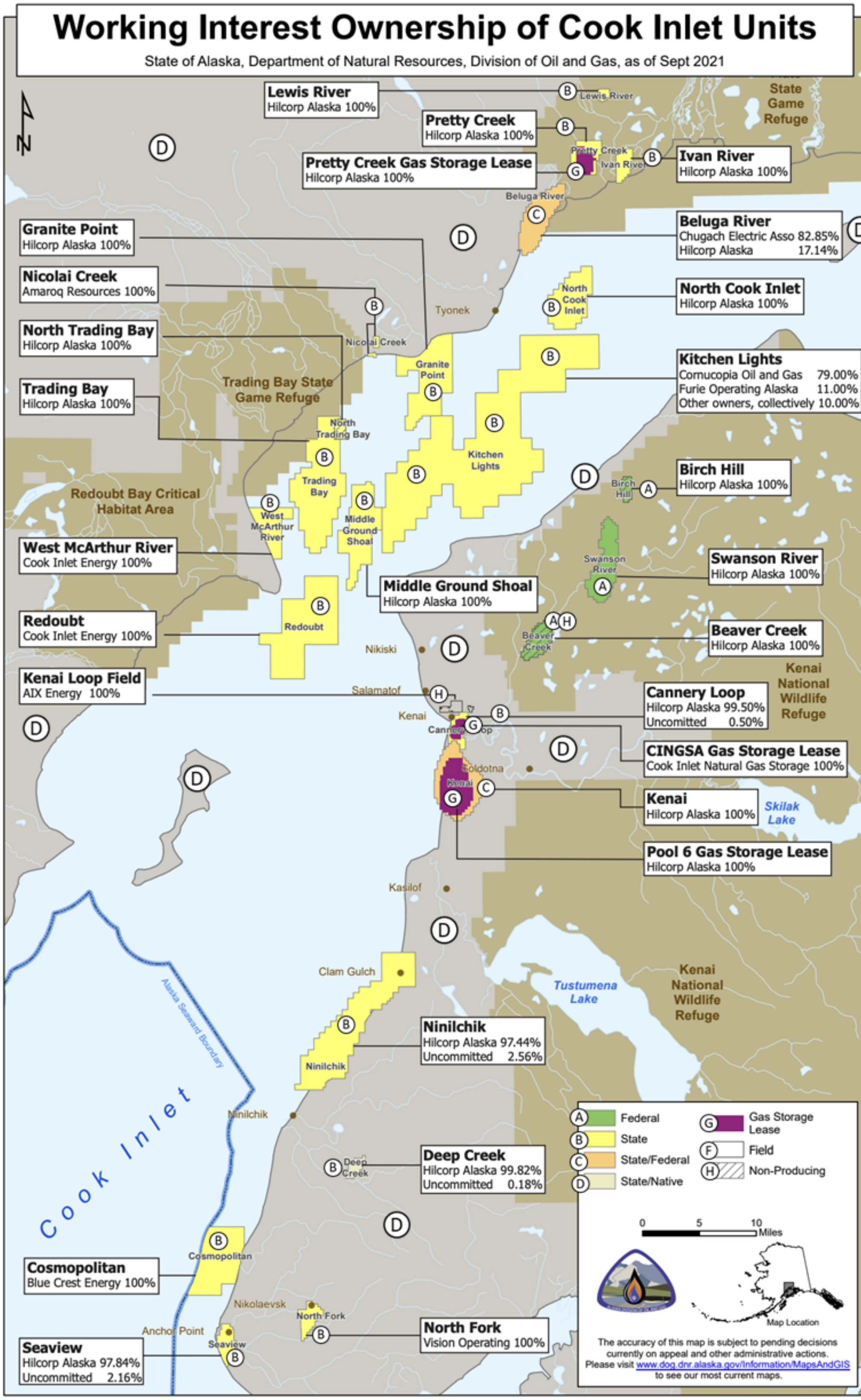

Figure 3-9. Cook Inlet, Alaska - Working Interest Ownership Map
Source: https://dog.dnr.alaska.gov/Information/MapsAndGIS (Accessed January 2022)

Source: NMFS (2019f)

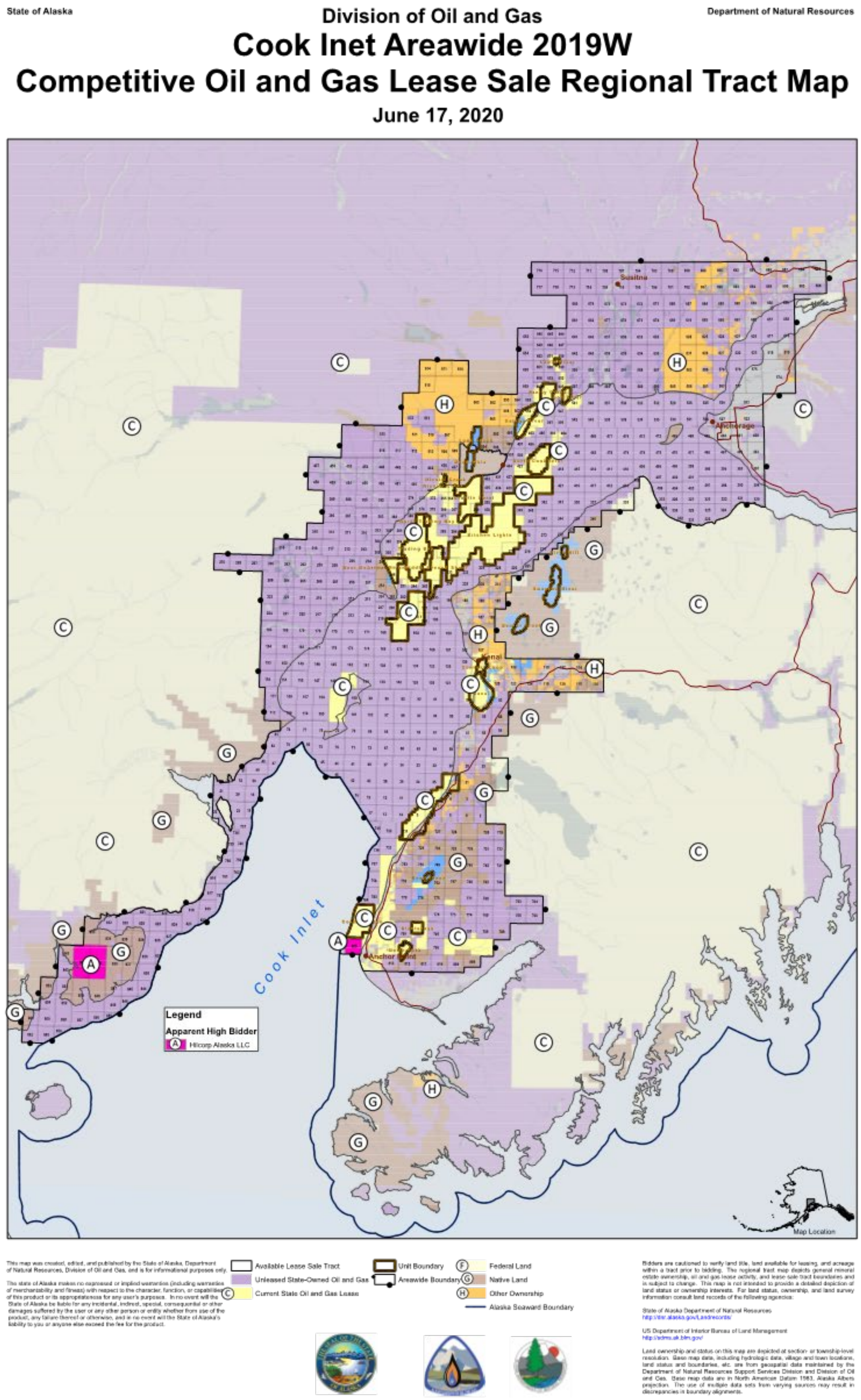

Figure 3-10. Cook Inlet Areawide 2019w Lease Sale Results

Source: https://dog.dnr.alaska.gov/Documents/Leasing/SaleDocuments/CookInlet/2020W/2020-04-17_Tract_Map_CIA_2020W.pdf; (Accessed August 16, 2020)

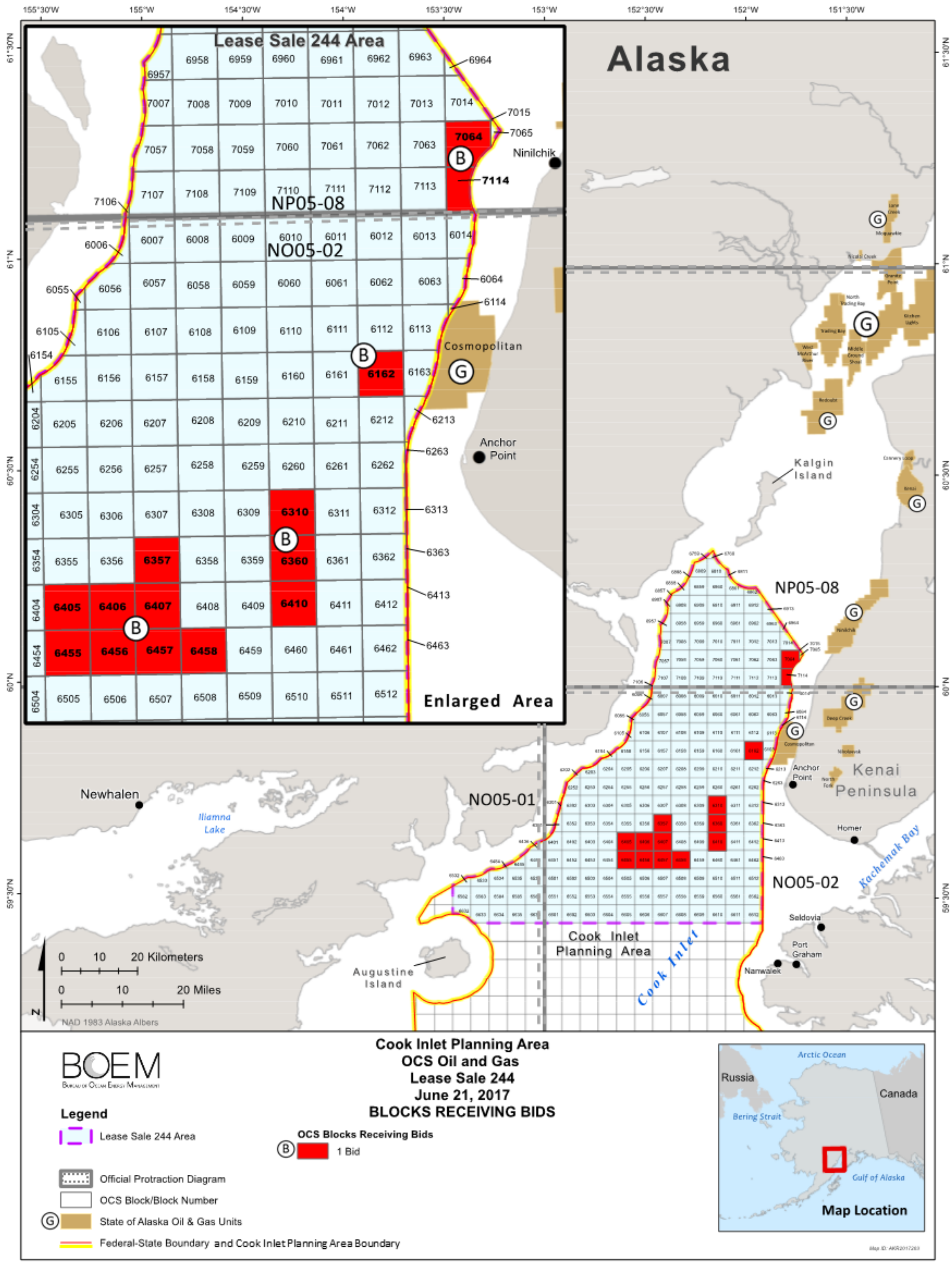

Figure 3-11. Cook Inlet Planning Area OCS Lease Sale 244 Bids

Source: https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Alaska-Region/Leasing-and-Plans/Leasing/Lease-Sales/Sale-244---Cook-Inlet/Bid-Distribution-Lease-Sale-Map.pdf; (Accessed August 16, 2021)

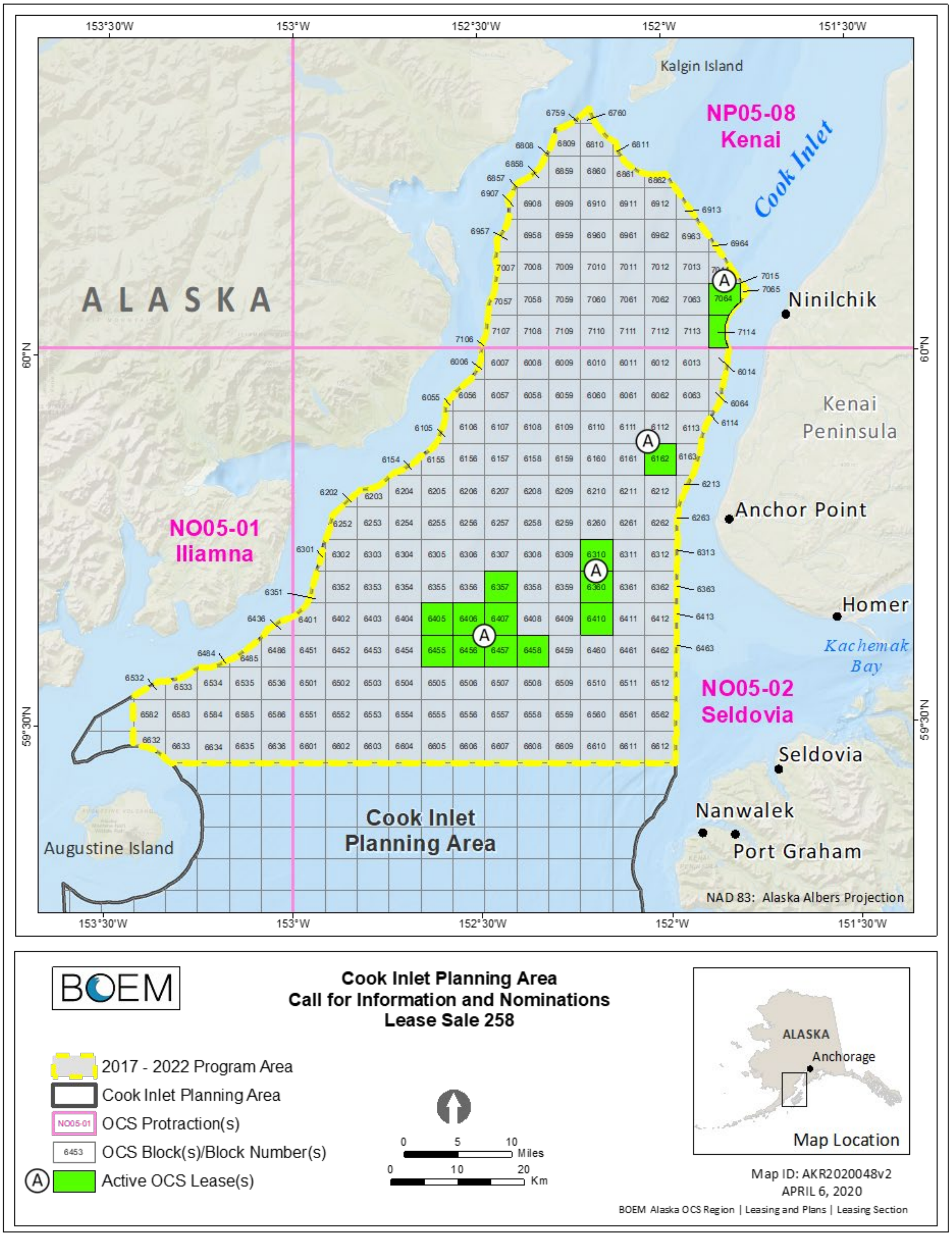

Figure 3-12. Cook Inlet Planning Area Lease Sale 258 Available Blocks

Source: https://www.boem.gov/sites/default/files/documents/oil-gas-energy/leasing/regional-leasing/alaska-region/sale-258-call-map.pdf; (Accessed August 16, 2021)

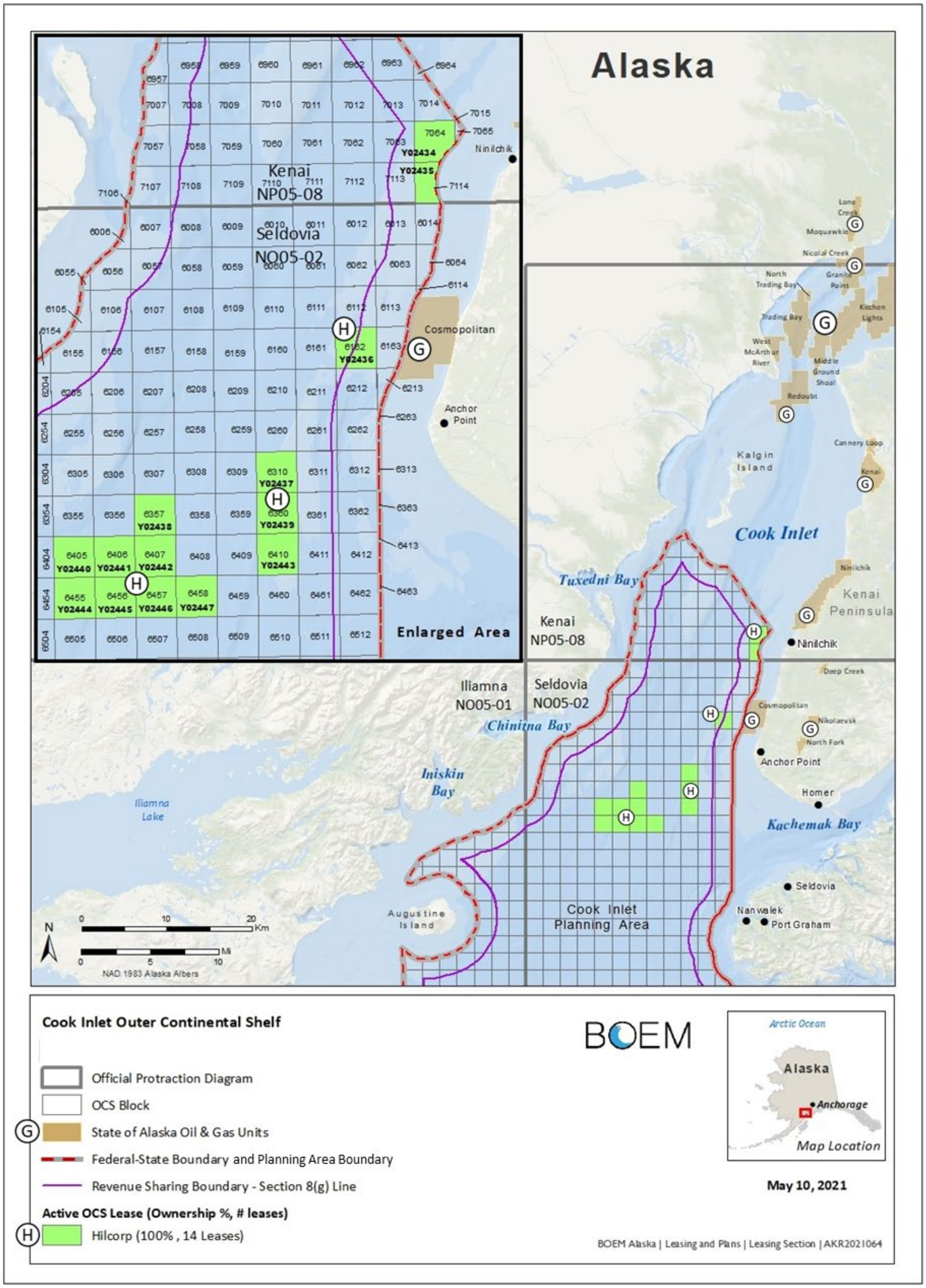

Figure 3-13. Active Federal Leases Cook Inlet Planning Area

Source: https://www.boem.gov/sites/default/files/documents/environment/COK-Map.pdf; (Accessed August 16, 2021)

3.2. Description of Oil and Gas Activities

The following descriptions provide a general overview of the types of oil and gas exploration, production/operation and decommissioning activities that have occurred in the Alaskan Beaufort and Chukchi seas and Cook Inlet for the period 2000 – 2020. Not all of the activities described have occurred each year but rather have been intermittent throughout the period as shown in Figures 3-2 and 3-3, above.

3.2.1. Seismic Surveys

3.2.1.1. Ocean Bottom Cable/Ocean Bottom Node Survey

Ocean bottom cable (OBC) seismic surveys acquire seismic data in transition zones where water is too shallow for large vessels needed to tow streamers (see Section 3.2.1.3) and too deep for grounded ice in the winter (NMFS 2008d, f, 2016f). A typical survey includes the use of several vessels: (a) two for cable layout/pickup; (b) one for recording; (c) one or two source vessels; and (d) possibly one or two smaller utility boats (NMFS 2008f, d).

Generally, a single source vessel is used, but additional vessels may be needed to accommodate the full airgun array. The overall energy output is the same regardless of the number of vessels, as the source arrays alternate vessels when firing (NMFS 2016f). OBC seismic arrays are frequently smaller in size than the towed marine streamer arrays (see Section 3.2.1.3) due to the shallower draft required for shallower water depths. Utility boats used to support the activity are small, in the range of 10 to 15 meters (m) (NMFS 2016f).

From NMFS (2016f):

> *An OBC operation begins by laying cables off the back of the layout boat. Cable length typically is 4 to 6 km but can be up to 12 km. Groups of dual component (2C) or multiple component (4C) seismic-survey receivers (a combination of both hydrophones and vertical-motion geophones) are attached to the cable in intervals of 12 to 50 m … Multiple cables are laid on the seafloor parallel to each other using this layout method, with a cable spacing of between hundreds of meters to several kilometers, depending on the geophysical objective of the seismic survey. When the cable is in place, a vessel towing the source array passes over the cables with the source being activated every 25 m. The source array may be a single or dual array of multiple airguns, which is similar to the 3D marine seismic survey.*
>
> *After a survey line is completed, the source ship takes about 10 to 15 minutes to turn around and pass over the next cable. When a cable is no longer needed to record seismic survey data, it is recovered by the cable-pickup ship and moved to the next recording position. A particular cable can lay on the seafloor anywhere from two hours to several days, depending on operation conditions. Normally, a cable is left in place for about 24 hours. While OBC seismic surveys could occur in the nearshore shallow waters of the Beaufort Sea, they are not anticipated to occur in the Chukchi Sea OCS because of its greater water depths and the exclusion of the near shore OCS area from leasing.*

Like OBC surveys, ocean bottom node (OBN) surveys place receivers on the seafloor. Oil and gas activities typically use four-component (4C) receivers including three orthogonal geophones and one hydrophone capable of measuring shear and compressional waves (NMFS 2016f). Remotely operated vehicles are often used to deploy groupings of nodes in deep water, while cables or ropes can be used to deploy nodes in shallow water. Node spacing depends on the depth of geologic targets but generally ranges between 50 and 500 m. A vessel is used to tow the source array perpendicular to receiver lines (NMFS 2016f).

While one grouping of nodes is recording, the source vessel will retrieve previous patches of nodes to download recorded data and to recharge them for another deployment. Pingers and transponders are used to locate the nodes for retrieval. Pingers operate at frequencies between 35 and 55 hertz (Hz) and source levels (SLs) of 197 decibels (dB) re 1 microPascal (µPa) at 1 m (NMFS 2013f). Short pulses from transponders also operate at frequencies between 35 and 55 Hz but at slightly lower SLs around 187 dB re 1µPa at 1 m (NMFS 2016f).

Airguns are used as sound sources for these surveys. Airgun arrays typically produce most noise energy in the 10 to 120 Hz range, with some energy output extending to 1 kilohertz (kHz) (Richardson *et al.* 1995). Airgun arrays are typically either 1240 cubic inch (in^3) or 620 in^3, with mitigation airguns being in the 40 cui range (NMFS 2015f). As described in Section 6.10, mitigation airguns are small volume devices used to deter marine mammals from the immediate area of the seismic operations prior to use of the larger arrays.

The spacing between airguns results in offset arrival of the sound energy. The offset energy waves partially cancel each other and blur the sound signature, thereby reducing the amplitude horizontally (NMFS 2015f). Marine mammals near the water surface and horizontal to the airgun arrays would receive lower sound levels than if situated directly beneath the array. Table 3-1 shows maximum sound SLs for equipment typically used during these types of seismic surveys.

Table 3-1. Sound Source Levels of Equipment Typically Used in Seismic Surveys

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1µPa at 1 m)
1,240 in^3 airgun array	<1	224
620 in^3 airgun array	<1	218
40 in^3 airgun array [1]	<1	195
Pinger	35-55	197
Transponder	33-55	187
Vessel noise[2]	<1	200

[1] Mitigation airgun
[2] Includes source, recorder, housing, and transport vessels
Source: NMFS (2015f)

3.2.1.2. Marine Deep Penetration Towed-Streamer 2D and 3D Surveys

Deep penetration surveys may include seismic surveys such as open-water, towed streamer two-dimensional (2D) or three-dimensional (3D) surveys, in-ice towed streamer 2D surveys, on-ice 2D or 3D surveys or ocean bottom receiver (cable or node; OBC); and controlled source electromagnetic surveys. Seismic data are collected over a specific area using a grid pattern. Data are then analyzed to construct a framework of the subsea geology to locate potential hydrocarbons.

During an open-water seismic survey by Shell July – September 2006, vessel sound measurements reported received levels at 500 m distance were 125–132 dB re 1µPa for the seismic ship *Gilavar*, and 127–135 dB for the chase vessel *Jim Kilabuk*, depending on aspect (bow, stern, broadside). Both ships were recorded in the Chukchi Sea. In the Beaufort Sea, the received broadband level for the tug *Henry Christoffersen* at 500 m distance was approximately 122 dB re 1µPa (Patterson *et al.* 2007).

3.2.1.3. Towed Streamer 2D and 3D Surveys

Airgun arrays and towed streamers are used to conduct 2D and 3D geohazard surveys. The 2012 NMFS BiOp (NMFS 2012e) describes seismic surveys that occurred in Simpson Lagoon:

> *Since 1996, many of the open water seismic surveys in State of Alaska waters and adjacent nearshore federal waters of the central Alaskan Beaufort Sea have been ocean-bottom cable surveys. These surveys were 3D seismic programs. The area to be surveyed is divided into patches, each patch being approximately 5.9 by 4.0 km in size. Within each patch, several receiving cables are laid parallel to each other on the seafloor. Seismic data are acquired by towing the airguns along a series of source lines oriented perpendicular to the receiving cables. While seismic data acquisition is ongoing on one patch, vessels are deploying cable on the next patch to be surveyed or retrieving cables from a patch where seismic surveys have been completed. Airgun arrays varied in size each year from 1996-1998 with the smallest, a 560 in^3 array with 8 airguns, and the largest, a 1,500 in^3 array with 16 airguns.*

Figure 3-14 shows a typical seismic vessel with towed streamers and source.

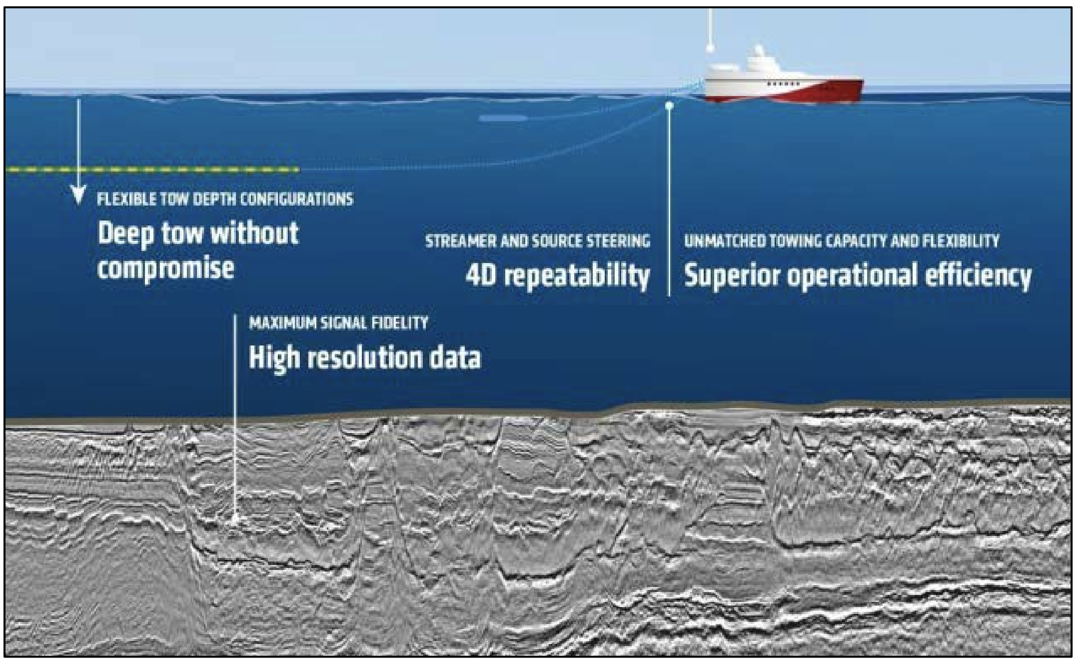

Figure 3-14. Diagram of Typical Seismic Vessel with Streamers and Source

Source: NMFS (2019f)

3.2.1.4. Vertical Seismic Profiling

Vertical seismic profiling (VSP) is used once the well is drilled. Accurate follow-up seismic data are collected by placing a receiver at known depths in the borehole and shooting a seismic airgun at the surface near the borehole (NMFS 2016f). Figure 3-15 depicts a VSP scenario.

Data obtained during VSP provide high-resolution images of the geological layers penetrated by the borehole and can be used to accurately correlate original surface seismic data. The actual size of the airgun array is not determined until the final well depth is known, but typical airgun array volumes are between 600 and 880 cui. VSP typically takes less than two full days at each well site (NMFS 2019f). See Table 3-1, above, for airgun sound SLs.

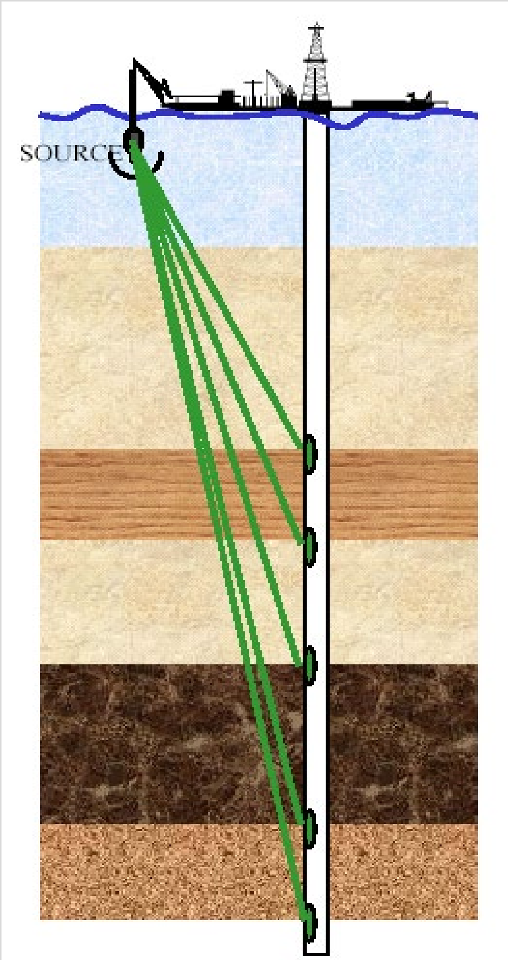

Figure 3-15. VSP Schematic

Source: Shell (2011)

3.2.2. Site-clearance and High-resolution Shallow Hazard Survey

High-resolution surveys or shallow hazard or site clearance surveys can use either acoustic sources to provide imagery of the seafloor and sub-seafloor to a depth of less than 1,500 m, or use sediment sampling devices to identify hazards. Acoustic sources include multibeam echosounders, Side-scan sonar, and sub-bottom profilers. Table 3-2 provides typical sound SLs for these acoustic sources.

Table 3-2. Sound Source Levels of Equipment Typically Used in Shallow Hazards Surveys

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1μPa at 1 m)
Mulibeam echosounder	200-400	220
Side-scan sonar	120-450	215
Sub-bottom profiler	2-16	216
Vessel noise[1]	<1	200

Source: NMFS (2014c)
[1] Includes source, recorder, housing, and transport vessels

3.2.2.1. Echosounder (Multi-beam or Single-beam)

Echosounders are generally hull-mounted or towed behind a single vessel (NMFS 2019f). The ship travels at 3 to 4.5 knots (kts) (5.6 to 8.3 km per hour). Surveys are site-specific and can cover less than one lease block in a day, but the survey extent is determined by the number of potential drill sites in an area. Multibeam echosounders emit high-frequency energy in a fan-shaped pattern of equidistant or equiangular beam spacing (NMFS 2014c).

3.2.2.2. Sub-bottom Profiler

Like echosounders, sub-bottom profilers are generally hull-mounted or towed behind a single vessel (NMFS 2019f). The purpose of the sub-bottom profiler is to provide an accurate digital image of the shallow subsurface sea bottom below the mud line (NMFS 2014c).

3.2.2.3. Side-scan Sonar

Side-scan sonar is a sideward looking, two channel, narrow beam instrument that emits a sound pulse and listens for its return (NMFS 2008b). The sound energy transmitted is in the shape of a cone that sweeps the sea floor resulting in a 2D image that produces a detailed representation of the seafloor and any features or objects on it. Like echosounders, the sonar can either be hull mounted or towed behind the vessel (NMFS 2014c).

3.2.2.4. Magnetometer

Magnetometers are used to detect magnetic deflection generated by buried or exposed ferrous objects, which may be related to archaeological artifacts or modern anthropogenic debris (NMFS 2014c). Magnetometers are towed at a sufficient distance behind the vessel such that the received data are not affected by the vessel's magnetic properties. Magnetometers measure changes in magnetic fields over the seabed and do not produce sounds. While there may be associated disturbance due to vessel presence, the magnetometer itself would not result in effects on marine mammals.

3.2.3. Non-impulsive Vibroseis

Surveys using vibroseis can be conducted on land or ice and use truck- or track-mounted vibrators that systematically put variable frequency energy into the ground surface or through the ice and into the seafloor (NMFS 2016f). At least 1.2 m of sea ice is required to support the required heavy vehicles; therefore, this technique is most commonly used on landfast ice or on stable offshore pack ice.

Survey crews move ahead of the operation and mark the source receiver points, followed by the vibration equipment. Activity on the seismic line begins with the placement of geophones (receivers) at the marked locations, which are connected to the recording vehicle by multi-pair cable sections (NMFS 2016f). Receivers are typically placed every 30–35 m and vibrator source points are placed at equivalent intervals (LGL Ltd. and Marine Acoustics Inc. 2011). The vibrators move to the beginning of a seismic survey line, begin vibrating in synchrony via a simultaneous radio signal to all vehicles, and recording begins.

The standard land (or on-ice) vibroseis unit emits a frequency sweep across the 5–90 Hz range (LGL Ltd. and Marine Acoustics Inc. 2011), with an estimated SL of 187 dB re 1µPa at 1 m (Richardson *et al.* 1995). Each sweep typically has a duration of 5–12 sec. Because of the length of the sweep and the silent periods between sweeps (also several seconds in duration), vibroseis signals are considered transient but not impulsive (LGL Ltd. and Marine Acoustics Inc. 2011).

Compared to airgun signals, vibroseis signals are generally lower in zero-to-peak sound pressure level (SPL) and root-mean-square (rms) SPL, they have reduced bandwidth [2–4], and are typically longer waveforms with shorter inter-signal intervals than airguns (Matthews *et al.* 2020).

3.2.4. Exploratory Drilling

Exploratory wells are drilled in areas not previously explored or near existing wells to find new oil and gas reservoirs. Seismic testing is typically conducted in these locations to determine the depth and thickness of potential sources of hydrocarbons. Exploration drilling occurs from ice pads, bottom-founded structures such as jackup rigs, and floating vessels or drill ships. As wells are drilled, engineers analyze various rock layers to determine which ones may contain organic-rich shale with potential sources of oil or natural gas. Exploratory wells are usually drilled only vertically, whereas horizontal drilling may occur if the well is believed to be productive (NMFS 2016f).

3.2.4.1. Drillships

A drillship is a maritime vessel that has been equipped with drilling equipment and a dynamic positioning system (NMFS 2016f). Drillship drilling units emit near continuous non-pulse sounds (NMFS 2015e) that are generally low-frequency (below 600 Hz) but tones up to 1,850 Hz have been recorded during drilling operations in the Beaufort Sea (Greene 1987). Greene (1987) recorded sound levels of 122 to 125 dB re 1 Pa between 20 to 1,000 Hz band level at a range of 0.17 km for the drillship *Explorer I*. Sound levels from the drillship *Explorer II* were slightly higher (134 dB) at a range of 0.20 km, and sounds from the *Kulluk* at 0.98 km were higher (143 dB) than from the other two vessels (Greene 1987).

Sound is also generated during positioning of the drill ship. Acoustic measurements were recorded while the drill ship *Discoverer* was located in water depths of 30 m in the South China Sea (Shell 2011). Recording occurred during repositioning of the drillship on its turret using the thrusters, tripping, drill string handling, drilling, and anchor retrieval (Table 3-3).

Table 3-3. Sounds Associated with Drillship Positioning

Measured Activity	Broadband Source Level (dB 1μPa at 1 m)		
	Forward	Side	Aft
Turret turning using jacking system	185.7	176.1	174.0
Turret turning using thrusters	191.5	182.8	180.7
Turret turning using main engine & rudder (dead slow ahead)	180.0	189.6	181.1
Turret turning using main engine & rudder (slow ahead)	182.3	187.6	194.6
Tripping	177.5	185.3	176.2
Drill string handling	178.7	185.1	177.6
Drilling	179.9	185.4	178.5
Anchor retrieval	197.6		

Source: Austin and Warner 2010, as cited in Shell (2011).

3.2.4.2. Anchor Management

The drillships are positioned and moored over the drill site with a system of anchors (generally eight anchors) supported by an anchor handling vessel (Shell 2011). Figure 3-16 depicts a typical anchor handling vessel, the *M/V Tor Viking*. When not conducting anchor handling duties, these vessels are available to provide other general support and some are used to provide secondary ice management (see Section 3.2.4.5) (NMFS 2015e).

As shown above in Table 3-3, sound generated from anchor handling can be as high as 197.6 dB 1μPa at 1 m (Shell 2011).

Figure 3-16. Anchor Handling Vessel

Source: Shell (2011)

3.2.4.3. Jackup Rigs

A jackup rig is an offshore structure composed of a hull and support legs, with a lifting system that allows the rig to be towed to a site, lower its legs into the seabed and elevate its hull to provide a stable work deck (NMFS 2016f). Jackup rigs have been used in Cook Inlet.

Underwater sounds from jackup rig drilling activities are generally from the use of generators and drilling machinery (NMFS 2016f). Sound levels transmitted into the water from bottom-founded structures are typically less than sound levels from drillships; in a jackup rig, the drilling platform is above water and the vibrating machinery is not in direct contact with the water. Measurements from the *Spartan 151* drilling rig operating in Cook Inlet indicated that the primary sources of underwater sound were produced by the diesel engines, mud pump, ventilation fans (and associated exhaust), and electrical generators (Marine Acoustics Inc. 2012, as cited in NMFS 2016f). The loudest SLs (from the diesel engines) were estimated at 137 dB re 1μPa at 1 m (rms) at a frequency of 141-178 Hz.

3.2.4.4. Support Vessels

Support vessels are used to assist drillships with icebreaking and ice management, anchor handling, oil spill response, refueling, resupply, personnel transport (and sometimes housing) and equipment servicing. Offshore drilling support work vessels are of steel construction with strengthened hulls to allow for working in extreme conditions (NMFS 2019f). Supply vessels are also capable of moving personnel when severe weather will not allow helicopter flights.

Oil spill response vessels (OSRV), including at least one barge (Figure 3-17), support exploration drilling and are often staged in the vicinity of drillships or platforms when drilling into potential liquid hydrocarbon bearing zones (NMFS 2015e). In the unlikely event of a well-control incident, the OSRV and containment barges provide initial containment, recovery and storage for the response (NMFS 2015e).

As shown in Table 3-2, the maximum sound SL for typical exploration support vessels is 200 dB re 1μPa at 1 m.

Figure 3-17. Oil Spill Response Barge

Source: Shell (2011)

3.2.4.5. Icebreaking Management Vessels

A typical ice management vessel, the *M/V Fennica* is depicted in Figure 3-18, below. Ice management includes both icebreaking and ice movement or "nudging".

Ice management generally produces the most intense sound energy associated with exploration drilling in the U.S. Arctic. The sounds are generally 10-15 dB higher during ice-breaking than when simply underway in open water or "nudging" ice floes (Shell 2011). The majority of the sound generated during ice management is produced by cavitation of the propeller, as opposed to the engines or by ice contacting the hull (Richardson *et al.* 1995; Shell 2011; Ireland *et al.* 2016). Reported sounds during ice breaking activities ranged from 174 to 184 dB 1μPa at 1 m (Shell 2011). As noted in Section 3.2.4.2, anchor handling vessels can be used to support ice management.

Figure 3-18. Typical Ice Management Vessel

Source: Shell (2011)

3.2.4.6. Aircraft Support

During offshore exploration efforts, helicopters are used to transport crews to drillships, platforms, or support vessels (Shell 2011; NMFS 2015e). Helicopters are also used to haul small amounts of food, materials, equipment, samples, and waste between vessels and the shore (NMFS 2015e). Fixed-wing aircraft, such as Saab 340-B 30-seat, Beechcraft 1900 19-seat, or DeHavilland Dash8 30-seat, are used to routinely transport crews, materials, and equipment between the shorebase for offshore locations and hub airports such as Utqiaġvik (formerly Barrow) or Fairbanks (Shell 2011).

Aircraft routes between land and offshore facilitates are chosen and followed based on weather conditions and whether subsistence users are active on land or at sea in the vicinity. Routes are modified depending on weather and subsistence uses (NMFS 2015e).

Fixed-wing aircraft, such as ta De Havilland Twin Otter (DHC-6), are often used to support marine mammal monitoring during offshore exploration drilling (Shell 2011). Aircraft are also used to support monitoring during seismic surveys. Figure 3-19 depicts line transects flown for marine mammal monitoring during a recent seismic survey in Lower Cook Inlet.

Received underwater sound levels from aircraft operating over offshore areas are summarized in Shell (2011). Sound levels ranged from non-detect to 123 dB at a 3-m water depth when a fixed-wing aircraft was overhead at 152 m. More recently, the MMPA final rule for the Liberty Development (NMFS 2019c) states:

> *While aircraft flying low directly overhead may be audible to a cetacean (whose ears are adapted to underwater hearing), it is highly unlikely that noise would cause changes to patterns of behavior that would rise to a level of a take.*

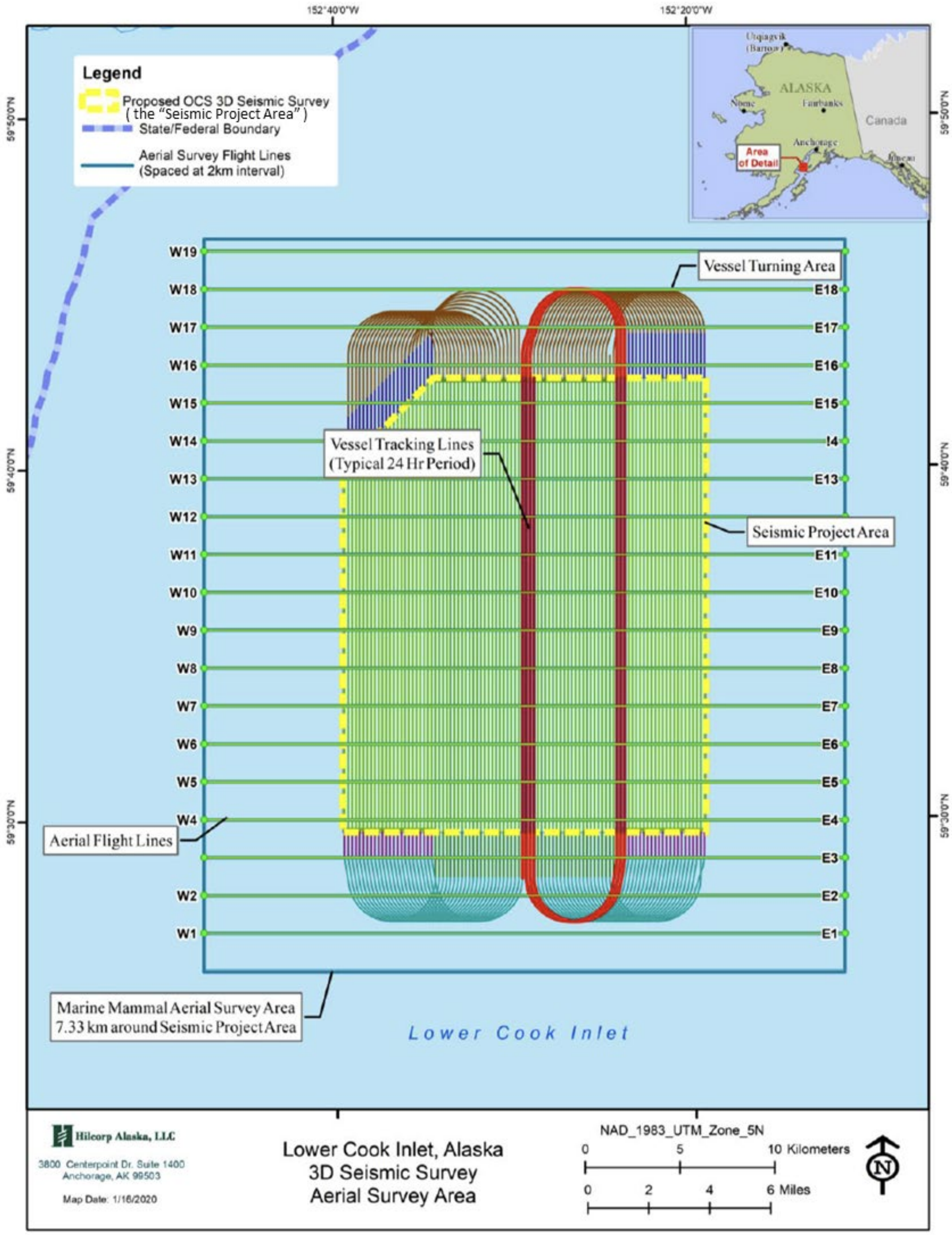

Figure 3-19. Lower Cook Inlet 3D Seismic Survey North-South Vessel Track Lines and East-West Aerial Transects for Marine Mammal Monitoring Overlaid

Source: Fairweather Science (2020)

3.2.5. Construction and Maintenance of Offshore Facilities

3.2.5.1. Gravel Placement

Gravel structures or islands are used to support oil and gas development and drilling operations in U.S. Arctic nearshore waters. To lessen environmental impacts, gravel is placed during the ice-covered season. Gravel is obtained from onshore gravel mines and transported by ice road to the island location. Sections of sea ice are cut and removed from the location of the offshore structure (NMFS 2019e). Once the ice is removed, gravel is poured through the water column to the sea floor. The island is built from the bottom up as a conical pile of gravel forms on the sea floor until it reaches the surface of the ice. Construction continues sequentially by removing additional ice and pouring gravel until the surface area is achieved.

Sound source verification (SSV) conducted during Northstar Island construction (Greene *et al.* 2008) and modeling conducted by SLR Consulting (SLR 2017), showed that ice cutting activities and trucks transiting on ice roads during ice-covered conditions result in average underwater SPLs of 169.6 and 179.1 dB re 1μPa at 1 m, respectively, and in-air sound SLs of 76.3 dB re 20μPa at 100 m and 74.8 dB re 20μPa at 100 m, respectively.

3.2.5.2. Slope Shaping and Armament Installation

To protect offshore gravel islands from erosive forces of waves, ice ride-up, and currents, armaments, such as linked concrete mats, are installed around the island edges (NMFS 2019e). An excavator is used to grade and smooth the gravel fill and linked concrete mats are installed to protect and stabilize the gravel island (Figure 3-20).

Based on the Greene *et al.* (2008) SSV study conducted during construction at Northstar and modeling conducted by SLR (SLR 2017), the use of an excavator or backhoe to grade and shape the island slopes typically results in average underwater SPLs of 177.7 dB re 1μPa at 1 m during ice-covered conditions (SLR 2017).

During open-water conditions, underwater SPLs would be 167 dB re 1μPa rms at 1 m (Richardson *et al.* 1995; SLR 2017). In-air sound SL of 78 dB re 20μPa at 10 m (SLR 2017).

Figure 3-20. Depiction of Linked Concrete Mat Armaments

Source: NMFS (2019e)

3.2.5.3. Sheet Pile Driving

Sheet pile is often installed around offshore structures such as gravel islands to provide additional protection from erosive forces of waves, ice ride-up, and currents (NMFS 2019e). A vibratory hammer which vibrates vertically, is initially used to drive sheet pilings (Shepard *et al*. 2001, as cited in NMFS 2019e). Pile penetration speed varies depending on ground conditions, but a minimum sheet pile penetration speed is 0.5 m per minute to avoid damage to pile or hammer (NASSPA 2005, as cited in NMFS 2019e). From a SSV study conducted at Northstar (Greene *et al.* 2008), data compiled by Caltrans (2007, as cited in NMFS (2019e), and modeling conducted by SLR Consulting (SLR 2017), it was determined vibratory hammers result in an average underwater SPL of 221 dB re 1µPa at 1 m during ice-covered conditions and 202 dB re 1µPa at 1 m during the open-water season. The in-air sound SLs are 81 dB re 20µPa at 100 m (Greene *et al.* 2008; SLR 2017).

To further set the piles deeper into the substrate, impact pile driving is often used after the sheet piles have been driven to a certain depth (NMFS 2019e). Generally, impact strike rates are 35 to 50 strikes per minute. Based on the findings of Greene *et al.* (2008), Caltrans (2007, as cited in NMFS 2019e), and modeling conducted by SLR Consulting (SLR 2017), impact hammer use to install sheet piles typically results in an average underwater SPL of 235.7 dB re 1µPa at 1 m during ice-covered conditions and 225 dB re 1µPa at 1 m during the open-water season (SLR 2017). The in-air sound SL or impact driving of sheet piles is 93 dB re 20µPa at 160 m (Blackwell *et al.* 2004a; SLR 2017).

3.2.5.4. Pile/Pipe Driving

In the Beaufort Sea, it is often necessary to drive conductor pipes for wells or other piles on offshore gravel structures. Conductor pipes are driven using impact hammers or vibratory drilling using augers (NMFS 2019e). Based on modeling conducted by SLR Consulting (SLR Consulting 2017, as cited in NMFS 2019e) and results from monitoring during Northstar Island construction (Blackwell *et al.* 2004a) the use of an impact hammer on 20-in conductor pipes resulted in an average underwater SPL of 171 dB re 1µPa at 1 m during ice-covered conditions and 200 dB re 1µPa at 1 m during the open-water season (SLR 2017). The in-air sound SL is anticipated to be 93 dB re 20µPa at 160 m (SLR 2017). If vibratory pipe driving or drilling methods are used, they are expected to generate less noise than impact driving (NMFS 2019e).

3.2.5.5. Dredging and Screeding

Dredging is used to maintain sufficient water depths at docks and offshore facilitates on the Alaska North Slope and in Cook Inlet. Dredging is accomplished by using an excavator and bucket from the deck of a barge. On the Alaska North Slope, dredged material is placed above mean high higher water (MHHW) (NMFS 2018e). Noise associated with the use of the excavator would be similar to that described for trenching (Section 3.2.5.6).

Screeding is a common practice at docks on the Alaska North Slope, including West Dock and the dock at the Point Thomson Central Pad, and is used to maintain a level area for vessel traffic (NMFS 2019g). Screeding is accomplished by moving sediments with a screeding device (a plow or rake-like structure) attached to a barge. The screeding device is controlled vertically using hydraulics (*i.e.*, a forklift located on the barge). No SLs for screeding have been measured; however, screeding may produce sound SLs similar to underwater backhoe trenching, as described in Section 3.2.5.6 (NMFS 2019g).

3.2.5.6. Pipeline Installation (Trenching)

3.2.5.6.1. Beaufort Sea

On the Alaska North Slope, offshore pipeline construction is usually accomplished during the ice-covered season to reduce environmental impacts. Offshore pipeline construction generally progresses from shallower to deeper water. Construction progresses as follows: mobilization of equipment, material, and crew members; construction of the supporting ice road (Section 3.2.5.8); cutting of a slot through the ice and excavating a trench (including temporary storage of excess materials); welding the pipeline bundle components; placing the pipeline bundle in the trench; and backfilling the trench (NMFS 2019e). Work is conducted from thickened ice using conventional excavation and dirt-moving construction equipment (*i.e.*, backhoe or excavator, Ditch Witch, booms, and trucks). After the pipeline bundle is lowered, the trench is backfilled using excavated trench spoils and additional backfill, if needed. Gravel or gravel bags are often used as trench backfill near the transitions to shore or the drilling island (NMFS 2019e). Offshore pipeline target trench depths are typically 2.7 to 3.4 m with a maximum depth of cover of backfill of approximately 2.1 m. Figure 3-21 depicts a typical pipeline trench. This type of pipeline installation is conducted in shallow water, where landfast ice occurs.

Activities and equipment associated with pipeline installation that produce underwater noise include the use of trucks on ice roads, backhoe digging or use of an excavator, and Ditch Witch for sawing of ice. Noise from ice-cutting activities and from trucks transiting ice roads is the same as described for gravel placement (see Section 3.2.5.1). Sound generated during trenching using a backhoe would be similar to that as described for slope shaping (see Section 3.2.5.2).

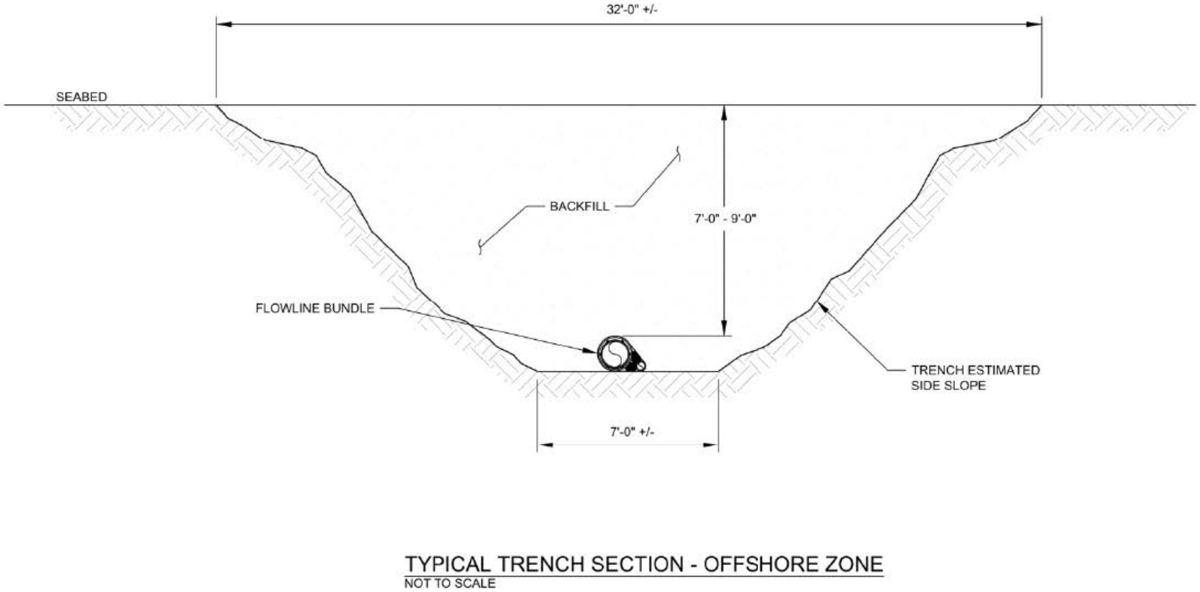

Figure 3-21. Beaufort Sea Offshore Pipeline Trench Schematic

Source: NMFS (2019e)

3.2.5.6.2. Cook Inlet

Pipeline construction in Cook Inlet waters generally begins at onshore fabrication and laydown areas (NMFS 2018b). The pipeline is manufactured onshore in 0.8 km segments, and each segment is inspected and hydrotested, and coatings are verified. Segments are welded together, welds are inspected, and coatings are applied to welds in the onshore fabrication area.

Following the connection of each new segment, an entire section of pipeline is pulled offshore using a winch mounted on an anchored pull barge. The barge must be intermittently repositioned by two tugs. An additional winch onshore maintains alignment of the pipeline during pulling (NMFS 2018b). The length of the pipeline to be pulled depends on the distance from shore the pipeline must cross and other site- and project-specific factors. Once the first section of pipeline is pulled offshore, the next segment is constructed, pulled into place, and connected to the first section with a subsea mechanical connection (NMFS 2018b).

Pipe pulling generally will occurs between slack tides, with repositioning occurring during the slack water periods. A sonar array, operating at frequencies above 200 kHz, is used to confirm that the pipe is being installed in the correct position. After installation, additional sonar surveys are conducted to confirm that pipeline placement is correct (NMFS 2018b). Once the pipeline sections are in place, seabed divers working from a boat adjacent the barge install sand or Sea-Crete bags on or under the pipelines for anchoring and stabilization on the seabed surface.

In intertidal zones, exposed pipelines are buried through the tidal transition zone. Burial in the transition zone is done by trenching adjacent to the pipeline using the open-cut method, placing the pipeline in the trench, and burying it to a depth of approximately 1.8 m (NMFS 2018b).

3.2.5.7. Pipeline and Infrastructure Maintenance, Repairs and Replacement

Natural gas and oil pipelines located on the seafloor of Cook Inlet are inspected on an annual basis using dive teams, ultrasonic testing (UT), cathodic protection surveys, multi-beam sonar surveys, and sub-bottom profilers (NMFS 2019f). Deficiencies identified are corrected using pipeline stabilization methods or U.S. Department of Transportation-approved pipeline repair techniques.

Scour spans of 15 m or greater identified using multi-beam sonar surveys are investigated using dive teams. Divers perform tactile inspections to confirm spans greater than 15 m. If scour spans are found, the pipeline is stabilized along these spans with Sea-Crete concrete bags (NMFS 2019f). Divers will also inspect the external coating of the pipeline and take cathodic protection readings if corrosion wrap is found to be absent.

3.2.5.8. Ice Road, Trail and Pad Construction, Operations and Maintenance

Ice roads and pads are constructed on the tundra to allow access to onshore locations and water sources. They are constructed by flooding freshwater over the surface until about 15 centimeters (cm) thick with a traveled surface width of approximately 9 m (BOEM 2018).

Sea ice roads are also constructed offshore on landfast ice to support drill sites (NMFS 2020d). Ice roads can be used by pick-up trucks, SUVs, buses, and other vehicles to transport personnel and equipment to and from an offshore site during the ice-covered period (NMFS 2020d). Offshore ice roads are generally about 18 to 31 m wide with 15 to 18 m shoulders on each side (Figure 3-22).

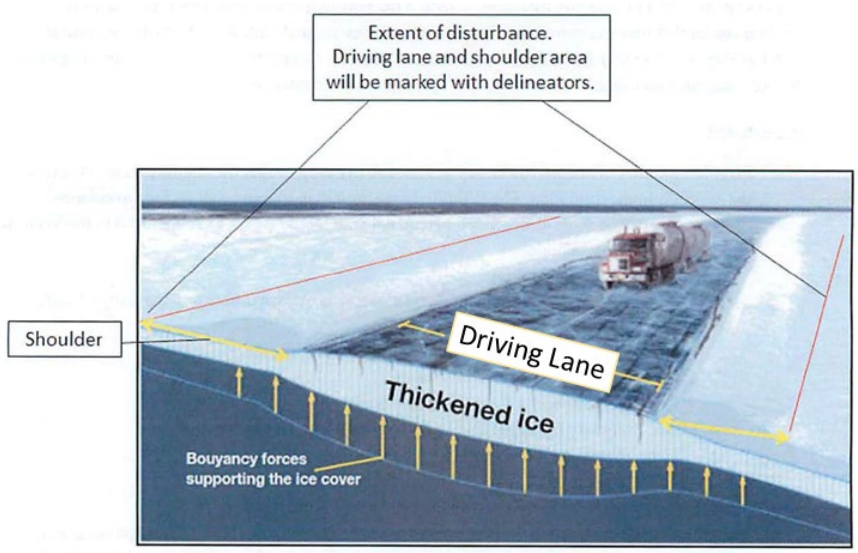

Figure 3-22. Sea Ice Road Diagram

Source: NMFS (2020d)

To construct an offshore sea ice road, the thickness of the ice is tested and if sufficient to support equipment, snow is cleared and graded from the proposed route (NMFS 2020d). Holes are drilled in the ice to pump seawater to the surface until the desired ice road thickness is reached. Flooding occurs 24 hours a day, 7 days a week, and is only halted in unsafe weather conditions. Materials, such as rig mats, are used to bridge small leads and wet cracks during construction and maintenance. The desired thickness for ice roads varies. For example, ice roads in water greater than 3 m deep must be 2.4 m thick to support construction equipment. In other instances, a 1.8 m thickness is sufficient (NMFS 2020d). In a method known as free-flooding, freshwater can be pumped over the road surface, providing additional strength. Ice roads on floating ice must be capped with a layer of freshwater; however, ice roads situated on grounded ice typically need minimal freshwater and free-flooding is used to either cap or repair cracks (NMFS 2020d). Sea ice pads to store equipment or provide for a drilling surface are constructed similarly.

Ice trails across sea ice are created, used, and maintained by tracked vehicles like Tuckers, Pisten Bullys®, and snowmachines (NMFS 2020d). Ice and snow are packed down by the large vehicles, and then allowed to thicken through natural freeze-up. Seawater flooding, freshwater ice caps, and snow removal, or large surface modifications are generally not required for ice trails. They vary in width, serve as unimproved access corridors, are not used by vehicles with tires, and are less elaborate and narrower than ice roads (*e.g.*, about 6 m wide) (NMFS 2020d).

Initiation off ice road, pad, or trail construction usually occurs in mid- to late December and ice roads are maintained until mid-May (BOEM 2018). Ice roads are maintained using graders with snow wings and blowers, front-end loaders with snow blower attachments, or personnel walking the route with snow blowers (NMFS 2020d). Large berms or large piles of snow are not created adjacent to the road or on the shoulders; wind direction is used to assist in dispersing the blown snow over a large area so that large berms or piles are not created. At the end of the season, ice roads and pads are barricaded by snow berms or slotted at the road entrance to prevent access and are allowed to melt naturally (BOEM 2018).

3.2.6. Drilling and Production

Once and offshore island is constructed or a jackup or other drilling platform is brought into place, additional wells are drilled, and the facility goes into the production phase. Process facilities (located either onshore, on an offshore gravel island like Northstar, or on platforms like Cook Inlet), separate crude oil from produced water and gas. On the Alaska North Slope, gas and water are injected into the reservoir to provide pressure support and increase recovery from the field. Crude oil, and in the case of certain Cook Inlet wells, natural gas, are delivered to distribution pipelines.

Richardson and Williams (2003) reported that drilling sounds from the Northstar Development had a maximum of 124 dB re 1µPa 1 km from the drill rig for the period 1999–2002. Blackwell *et al.* (2004a) determined that for Northstar, the highest broadband SPL (124 dB re 1 µPa) was recorded during drilling at a location 1 km east of the island, and that received levels during drilling tended to be higher. The authors infer that the distance at which broadband values reached a minimum in the absence of drilling was 3–4 km from the island during oil production at Northstar, and that production did not increase broadband levels for any of the sensors (Blackwell *et al.* 2004a).

More recently, the MMPA final rule for the Liberty Development (NMFS 2019c), estimated that during the ice-covered and open-waters seasons, underwater sound SLs from drilling and production would be 170.5 and 151 dB re 1µPa. Airborne noise from drilling and production was estimated to be 80 dB re 20µPa 200 m from the source.

3.2.7. Marine Transit Route Dutch Harbor to Alaska's North Slope

The marine transit route includes waters within the Bering, Chukchi, and Beaufort seas through which vessels transit between Dutch Harbor and the Alaska North Slope (NMFS 2019g). Figure 3-23 provides an example marine transit route from the Beaufort Sea to Dutch Harbor. Vessels would have a short-term presence in the Bering Sea as they transit to drilling operations in the Chukchi and Beaufort seas (Shell 2015). Drilling materials, food, fuel, and other supplies are picked up in Dutch Harbor and transported to drillships and support vessels during exploration and to West Dock for distribution to existing onshore and offshore oil and gas operations (NMFS 2015e). For some operations, staging and resupply also can occur from U.S. Arctic communities (*i.e.*, Nome, Kotzebue, Wainwright, Utqiaġvik, Prudhoe Bay, and Deadhorse) (Shell 2015).

For the marine transit route, Bisson *et al.* (2013) determined a sound SL of approximately 167 dB at 1 m associated with oceanic tug boat noise. This was anticipated to decline to 120 dB re 1μPa rms within 225 m of the vessel, assuming a spherical spreading loss coefficient of 20.

Figure 3-23. Example Marine Transit Route from the Beaufort Sea to Dutch Harbor

Source: BOEM (2018)

3.2.8. Safety Exercises and Spill Preparedness

The Bureau of Safety and Environmental Enforcement (BSEE) regulations for oil spill response requirements are found in 30 CFR Parts 250 and 254 (BOEM 2019). Specifically, requirements for oil spill preparedness require that unannounced drills are conducted to ensure compliance with oil spill response plans, that spill response and management teams receive appropriate spill response training, and that oil spill response equipment is routinely inspected. Training must include: locations of response equipment; intended use, deployment strategies, and operational and logistical requirements for response equipment; spill-reporting procedures; oil spill trajectory analyses and predictions of spill movement; and other team-specific responsibilities (BOEM 2019). BSEE requires that an annual deployment of response equipment must occur. These and other government-initiated unannounced spill planning exercises (*e.g.*, oil spill drills), are infrequent, of short duration (less than 8 hours), and utilize existing equipment (BOEM 2018).

3.2.9. Decommissioning

When planned and permitted operations are completed, wells would be suspended according BSEE regulations or other regulations in place at the time. Additionally, post-decommissioning surveys would be determined based on regulations in place at the time of decommissioning. Surface facilities would be de-energized, flushed of any residues, and removed. Wellheads, pilings, and other structures would be cut below the mudline. Modules would be removed in a reverse process from installation and transported to an offsite location to be reused, recycled, or disposed (ABSG Consulting Inc. 2018; NMFS 2019e). Any contamination would be remediated. Armoring and other slope protection would be removed from offshore islands and the island would be allowed to erode. As described in Section 3.2.5.8, sea ice roads would be allowed to melt naturally.

When the well is abandoned, the production casings are sealed with mechanical plugging devices and cement to prevent the movement of reservoir fluids between various strata. Each casing string is cut off below the surface and sealed with a cement plug. A final shallow cement plug is set to approximately 3 m below the mudline. At this point, the surface casing, conductor, and drive pipe is cut off pulled to the deck of the jackup rig for final disposal (NMFS 2019f). In the U.S. Arctic and Cook Inlet, buried subsea pipelines generally would be abandoned in place. Following flushing, the operator would verify that all hydrocarbons or other contaminants have been removed, cut the ends of the pipeline off at the appropriate elevation, and permanently seal the ends (NMFS 2019e). The locations of remaining marine lines would be identified for proper chart U.S. Coast Guard (USCG) designations to navigation marking, if appropriate. Additional details of decommissioning the subsea buried pipeline would be determined in the permitting or decommissioning approval process (ABSG Consulting Inc. 2018; NMFS 2019e).

4. Types of Potential Effects of Oil and Gas Activities on Marine Mammals That Could Occur Without Mitigation

This chapter describes the types of effects on marine mammals that may occur during exploration, construction, operation or decommissioning of oil and gas resources without considering mitigation and monitoring measures. Potential effects on marine mammals may be lumped into broad categories including physiological effects, mortality or serious injury, behavioral disturbance, and habitat alteration. Table 4-1 presents a simple overview of these potential effects of oil and gas activities if mitigation measures or monitoring of shut down zones were not implemented. Chapter 7 provides a summary of documented effects on marine mammals based on monitoring reports and literature, with specific focus on the U.S. Chukchi and Beaufort seas, and Cook Inlet, taking into consideration the mitigation and monitoring required through regulatory permits, authorizations, and consultations.

Table 4-1. Effects of Oil and Gas Activities that Could Occur Without Mitigation or Monitoring

Activity	Disturbance (including Noise)	Serious Injury or Mortality	Physical Habitat Alteration
2D and 3D Seismic Surveys	T	P	T
Site Clearance and High-Resolution Shallow Hazard Surveys	T		T
Non-Impulsive Vibroseis	T		
Ice Breakers and Ice Management	T		T
Ice Roads, Trails and Pads (Construction, Maintenance, and Use)	TR		TR
Exploration Drilling	T		T
Pile Driving (Impact or Vibratory)	T	P	P
Pile or Facility Removal	T		P
Dredging / Screeding	TR		TR
Pipeline Installation & Maintenance	TR		
Offshore Structure Construction (Gravel Island, Dock, Dock Extension)	T, P*		P
Vessels	TR	P	TR
Anchor Handling	T		T
Aircraft	TR		
Initial Drilling Into Reservoir	T		P
Production (Operations Drilling)	P		
Emergency Oil Spill Response Exercises	TR		
Slope Inspection & Topographic Surveys	T		
Ground Transportation	TR		
Decommissioning Activities	T		

Key: T = temporary; TR = temporary but reoccurring; P = Permanent or Chronic
* Construction phase considered temporary but structure would be permanent until decommissioning (if removed).

4.1. Behavioral Disturbance Due to Noise or Physical Presence of Human Activity or Structures

Marine mammals may be disturbed by oil and gas activities due to underwater or in-air noise, or physical presence of humans, vessels, aircraft, or other infrastructure. The primary direct and indirect effects on marine mammals, especially baleen and toothed whales, from activities associated with oil and gas exploration in the Beaufort and Chukchi seas has resulted from noise exposure due to underwater or in-air noise, or physical presence of humans, vessels, aircraft, or other infrastructure. Sources of noise during oil and gas activities during the period 2000 – 2020 included 2D/3D seismic survey equipment (airgun arrays), echosounder and sonar devices associated with site clearance and shallow hazards surveys, monitoring and receiving vessels associated with these surveys, icebreaking activities, on-ice vibroseis seismic surveys (Beaufort Sea only), exploratory drilling, and helicopter and fixed-wing aircraft associated with the different programs. Airgun arrays, the most common source of seismic survey noise, can propagate horizontally for many kilometers (Greene and Richardson 1988).

As evident in the literature reviewed for this report, there is ongoing discussion regarding how to define the biological significance of an effect on an animal or population. Fleishman *et al.* (2016) acknowledge the complexities of determining the basis to quantitatively defining concepts such as negligible impact, adverse impact, or recovery (*i.e.*, risk characterization), particularly considering the variable responses marine mammals have to stimuli and the multitude of other factors during an exposure. Despite the uncertainties as to whether an effect is biologically meaningful, research has provided some level of understanding regarding the types of effects that can occur. The following include general descriptions of the effects and potential consequences of oil and gas activities on marine mammals, as documented in literature during the general period 2000 – 2020. Chapter 7 provides documentation of effects of oil and gas on marine mammals (or lack thereof) from the Beaufort and Chukchi seas and Cook Inlet.

4.1.1. Fundamentals of Underwater Noise and Marine Mammal Hearing

Sound is comprised of a pressure component and a particle motion component. The current understanding is that marine mammals are generally more sensitive to SPLs than particle motion due to functional limitations, though the latter is not well understood (Finneran *et al.* 2002). When discussing sound measurements, there is a distinction between a sound SL and a received level (RL). As the terms imply, SLs are measured in the near proximity (*e.g.*, 1 m) to the source, whereas RLs are measured at a specified distance or estimated for a given distance from the source. The following terms and definitions are provided for quick reference.

- **Frequency**: Underwater noise is expressed as frequency bands, Hz or kHz, which are broadly characterized into three categories:
    - Low: 10 to 500 Hz
    - Mid: 500 Hz to 25 kHz
    - High: >25 kHz

    Low-frequency sounds include many anthropogenic sources such as commercial shipping and seismic exploration. The mid-frequency band is comprised of natural and anthropogenic noise sources that do not propagate over long ranges such as sonar or small vessels. Acoustic attenuation for high-frequency sound sources is so extreme that sound sources are confined to an area within a few km of the source such as shallow-water echosounding. Figure 4-1 and Table 4-2 depict the levels and frequencies of several natural and anthropogenic sounds.

- **Continuous Sounds**: These are sounds where the acoustic energy is spread over time, typically many seconds, minutes, or even hours. The metric most suitable for continuous sounds is SPL.

- **Cumulative Sound Exposure Level (cSEL)**: This is the total sound exposure level (SEL) determined for an extended period or sequence of pulses/events.
- **Decibel (dB):** a logarithmic measure of the amplitude of two quantities that have the same units (*i.e.*, so the ratio is unitless). The standard unit for acoustic pressure is µPa.
- **Pulsed (Impulsive) Sounds**: Impulsive or pulsed sounds are characterized by short bursts of acoustic energy of finite duration. Examples of pulsed sound are produced by marine pile driving, explosions, and airgun sources. SEL may be considered as a proxy for a measure of the pulse energy content.
- **Received Level (RL)**: An imprecise term meaning the level of an acoustic quantity at a specific spatial position within an acoustic field, usually the position of a marine receptor.
- **Sound Exposure Level (SEL)**: Numerically equivalent to the total sound energy. SEL is a measure of energy that considers both the RL and duration of exposure.
- **Source Level (SL)**: Sounds measured at or near the source (typically at 1 m or 10 m, for example). Sound SLs are an important component for assessing the potential distance at which a noise may be heard by a receptor (*i.e.*, received level).
- **Temporary Threshold Shift (TTS) versus Permanent Threshold Shift (PTS)**: A noise-induced threshold shift (TS) is ascribed to animals that have been exposed to sufficiently intense sounds and experience an increased hearing threshold (*i.e.*, poorer sensitivity) for some period following exposure. If TS eventually returns to zero (*i.e.*, the threshold returns to the pre-exposure value), it is called a temporary threshold shift (TTS). If after a relatively long interval (on the order of weeks), the TS does not return to zero, the residual TS is called a noise-induced permanent threshold shift (PTS).

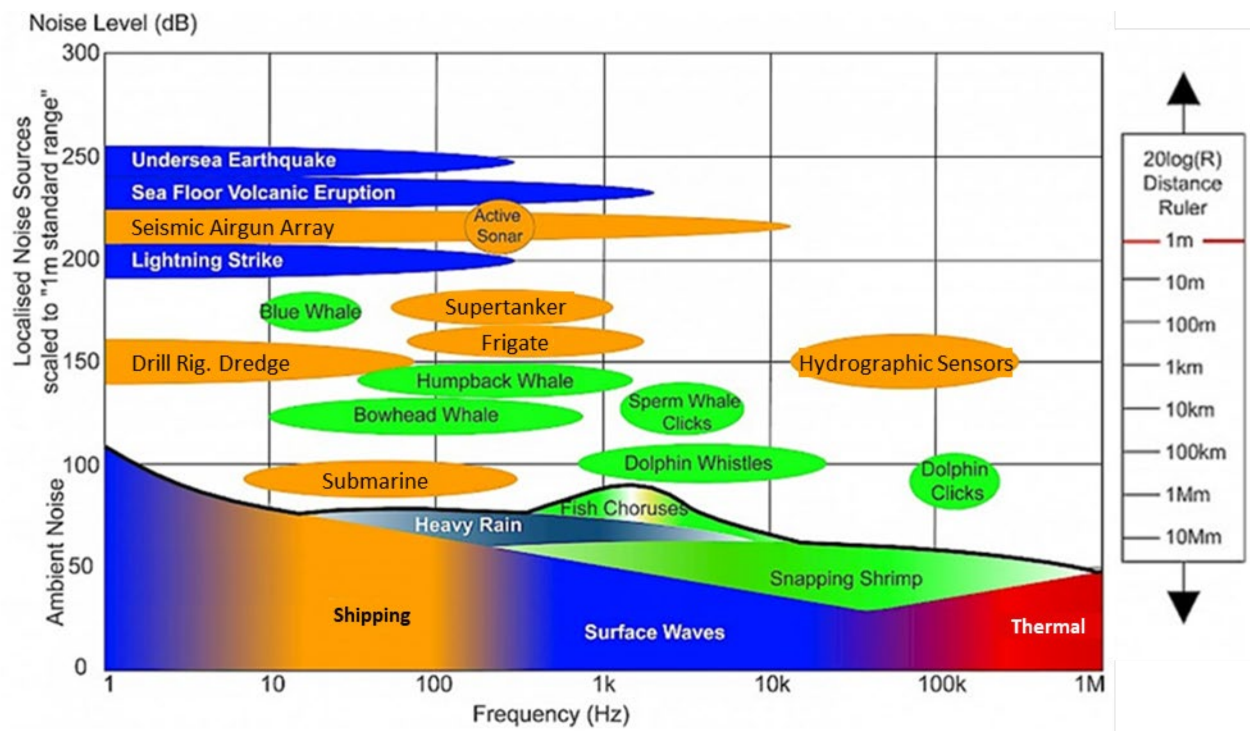

Figure 4-1. Levels and Frequencies of Anthropogenic and Naturally Occurring Sound Sources in the Marine Environment

Source: www.ospar.org/work-areas/eiha/noise (Accessed August 12, 2021)

Table 4-2. Frequency Range and Sound Levels for Various Sources

Sound Producing Factor	Frequency Range	Output at Source
Drilling Noise	Peak frequencies < 500 Hz, dominated by sharp tones < 100 Hz with little high-frequency noise	59–185 dB re 1μPa Drilling platforms typically 169 dB re 1μPa during
Dynamic Positioning Ships with Thrusters/Propellers [1]	10 Hz–10 kHz, with major components below 100 Hz	140–190 dB re 1μPa Low tonal peaks can be heard for several km
Commercial Shipping	5 Hz–100 Hz	150–195 dB re 1μPa
Small Vessels Traveling at Speed	10 Hz–11 Hz	170–180 dB re 1μPa
Helicopters	Typically < 500 Hz	Affected by helicopter altitude, blade pitch and power setting, distance, water depth, receiver depth, etc.
Risers, Well Head Valves, Flow Lines	Generally low-frequency	Various
Caviblaster®	31.5 to 8,000 Hz [2]	135–170 dB, [2] 176 dB [3]
Underwater Diamond Saw (*i.e.*, Cutting Edge Undersea Saw)	20–25 kHz [3]	~100 dB [4]
Ditch Witch (Sawing through Ice)	0–500 Hz	169.6 dB re 1μPa
Backhoe	0–500 Hz	177.7 dB re 1μPa
Concrete Pile Cutter (*i.e.*, Prime® Concrete Pile Cutter Model 24)	N/A	Avg. SPL 138–144.6 dB [5]
Sub-Bottom Profilers	0.4–24 kHz	Peak 214 dB re 1μPa
Side-Scan Sonar	100 kHz–500 kHz	Peak 234 dB re 1μPa
Single-Beam Echosounder	Low: 10–50 kHz High: 100–750 kHz	230 dB re 1μPa
Multibeam Echosounder	200 kHz–400 kHz; 700 kHz	Peak 220 dB re 1μPa
Seismic Airgun Array	5–300 Hz, but most concentrated around 50 Hz	230–260 dB re 1μPa

[1] Dynamic positioning uses thrusters/propellers so the vessel remains on station
[2] Source: Navy (2014)
[3] Source: Austin (2017)
[4] Source: Pangerc *et al.* (2016); measured at 100 m from source
[5] Source: NMFS (2016d)

As an update to Southall *et al.* (2007), Southall *et al.* (2019b) provided revised noise exposure criteria for marine mammals including estimated audiograms, weighting functions, and underwater noise exposure criteria for temporary and permanent auditory effects for six species groups. Noise sources were categorized as either impulsive (*e.g.*, impact pile driving) or non-impulsive (*i.e.*, continuous noise such as drilling). Based on the 2007 paper, regulatory thresholds were developed to account for species-specific sensitivities of marine mammals to different frequencies. Recognizing this important factor, the 2018 NMFS revised *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2018f) uses marine mammal hearing groups defined by Southall *et al.* (2007) with some modifications based on recent studies (Table 4-3).

Table 4-3. Generalized Hearing Ranges for Marine Mammal Hearing Groups in Water

Hearing Group	Hearing Range[1]
Low-Frequency Cetaceans (LF) (baleen whales)	7 Hz to 35 kHz
Mid-Frequency Cetaceans (MF) (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-Frequency Cetaceans (HF) (true porpoises, Kogia, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) and Other Non-Phocid Marine Carnivores (O)[2] (sea lions and fur seals)	60 Hz to 39 kHz

Source: NMFS (2018f)
[1] Represents the generalized hearing range based on sound sources for the entire group as a composite (*i.e.*, all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall *et al.* 2007) and PW pinniped (approximation).
[2] This group includes sea otters and walrus.

Marine mammal behavioral responses to stimuli are extremely variable depending on a host of factors, including exposure level, animal activity at the time of exposure, and environmental conditions. Avoidance is a common behavioral response to underwater sound exposure. These are typically the types of responses seen in species that do clearly respond, such as harbor porpoises, around temporary/mobile higher frequency sound sources in both the field (Johnston 2002) and in the laboratory settings (Kastelein *et al.* 2000; Kastelein *et al.* 2005; Kastelein *et al.* 2008a; Kastelein *et al.* 2008b). However, what appears to be more sustained avoidance of areas where high-frequency sound sources have been deployed for long durations has also been documented in some odontocete cetaceans, particularly those like porpoises and beaked whales that seem to be particularly sensitive (Southall *et al.* 2007; Carretta *et al.* 2008). While low-frequency cetaceans and pinnipeds have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high-frequency sound exposure (Kastelein *et al.* 2005).

The context of a marine mammals' exposure to underwater sounds is an important consideration when evaluating potential effects in terms of behavioral response (Ellison *et al.* 2018). Ellison *et al.* (2016) proposed use of SEL to better evaluate impacts of anthropogenic noise caused by oil and gas production, seismic surveys, and vessel traffic. The authors explored how changes in movement paths of simulated animals, which were programmed to avoid certain received levels of sound, would change sound exposure and travel distance of bowhead whales in the western Arctic (*i.e.*, 144−152°W) during the fall migration. Key to this analysis was estimating the aggregated received sound level for each simulated animal, which was done by summing the received sound energy for each source. Bowhead whale movement and diving behavior was based on available satellite telemetry and aerial survey data. The authors reported that "aversion behavior" to anthropogenic noise substantially changed the modeled results. That is, rather than a high proportion of animals being exposed to 155 to 160 dB sound levels, less than 50 percent (%) of simulated animals would be exposed to that sound level, assuming "aversion behavior" by bowhead whales. The authors emphasized the importance of quantifying the time-varying dynamics of animal behavior and the soundscape over periods of time that were ecologically meaningful. A similar conclusion was reached by Nowacek *et al.* (2015).

Watkins (1986, as cited in NMFS 2013c) reviewed behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales exposed to various sources of human disturbance. Based on the review, minke, fin, humpback, and North Atlantic right whales ignored sounds: at relatively low received levels; from distant activities; and activities with frequencies outside the whales' hearing ranges. Most negative reactions (*i.e.*, a behavioral response) occurred within 100 m of a sound source or when sudden increases in received sound levels were estimated to be greater than 12 dB relative to ambient sounds.

4.1.2. Soundscape and Acoustic Habitat

Halliday *et al.* (2020) reviewed available literature regarding ambient noise in the Arctic, as well as the reactions of Arctic and sub-Arctic marine mammals to anthropogenic sound. Loss of sea ice has led to increased human activity in the Arctic and there is general concern over the potential adverse impact of anthropogenic sound on marine mammal populations mediated through masking of underwater communication or the degradation of the information content of underwater communication.

From the perspective of anthropogenic noise levels in the marine habitat used by bowhead whales [and other marine mammals in the Chukchi and Beaufort seas], it is generally accepted that noise related to vessel traffic will increase as the open-water period in the U.S. Arctic lengthens (Huntington *et al.* 2016). PAME and Council (2019) reported that anthropogenic noise produced by shipping could have adverse effects on Arctic species. PAME and Council (2019) summarized the potential effects of underwater noise on marine mammals in the Arctic and provides an overview of the current knowledge on the topic. Key findings included: 1) ambient sound levels in the Arctic Ocean are generally less than in other oceans; and 2) the most common sound sources in the Arctic are vessels traffic and oil and gas activities. However, it should be noted that while vessel traffic is increasing over time, oil and gas activities are generally not (PAME and Council 2019).

Bonnel *et al.* (2021) quantitatively compared ambient acoustic data with environmental data from the Canadian Beaufort Sea including ice concentration, wind speed, and global ice drift. These are three parameters known to affect ambient sound based on a passive acoustic dataset recorded on the Chukchi Shelf from October 2016 to July 2017 (referred to as the Canada Basin Acoustic Propagation Experiment). The study focused on low-frequency (250 to 350 Hz) ambient noise (after individual transient signals are removed) and its environmental drivers. The Chukchi Shelf ambient noise shows traditional polar features: it is quieter and wind force influence is reduced when the sea is ice-covered (Bonnel *et al.* 2021).

It should be noted that during certain open-water seasons, depending on the level of activity occurring year-to-year, the ambient acoustic conditions in migratory corridors important to bowhead feeding or migration may be ensonified above 120 dB. At these sound levels, either masking of communication or reduced information transfer may occur as mothers and calves pass through (Blackwell and Thode 2021). For example, NMFS (2016f) stated that some limited masking of low-frequency sounds (*e.g.*, whale calls) was a possibility during seismic surveys. However, it was determined that seismic surveys would not occur over the entire Beaufort Sea at any one time, that the intermittent nature of seismic source pulses (1 second in duration every 16 to 24 seconds (*i.e.*, less than 7% duty cycle) would limit the extent of masking could occur, and that overall any impact on bowhead whale communication behavior would be minor, if any (NMFS 2016f).

4.1.3. Changes in Feeding Behavior

Changes in feeding behavior could stem from alteration of the foraging habitat itself (*e.g.*, placing permanent structures on the seafloor or in the water column) or due to disturbance. If a disturbance due to underwater or in-air sound, the presence of human activities, or vessel activities displaces a marine mammal from an important foraging or breeding area for a prolonged period, impacts on the animals or the population could occur if other suitable foraging habitat is unavailable or if the alternative foraging area or prey requires considerable energy to locate or consume.

The fitness of an animal can be affected by changes to an individual's energy budget, time budget, or both. Large whales, such as bowhead or humpback whales, can store large amounts of energy, which allows them to survive for long periods during migration or in overwintering areas.

Smaller cetaceans, like Cook Inlet beluga whales, likely forage year-round on seasonally available prey (*e.g.*, belugas congregate at anadromous streams when eulachon or salmon are running). Increases in energy costs related to the amount of time a marine mammal spends at the ocean's surface, increases in swimming speed, changes in direction to avoid vessel or other oil and gas operations, changes in respiration rates, increases in dive times, reductions in feeding efficiencies, or changes in energy required to vocalize all have the potential to impact the overall fitness of an animal (NMFS 2017b).

4.1.4. Changes in Migratory Behavior

Marine mammals that may be disturbed by human activity may choose to move to a different location. Such decisions are influenced by the availability of and quality of resources at alternative locations, and the condition of the marine mammal faced with the exposure (Bejder *et al.* 2009).

Stone (2003, as cited in NMFS 2013c) noted:

> *Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good visibility, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997, 1998, 2000, 2001). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003).*

In-ice seismic surveys are designed to begin in early to mid-October towards the end of the bowhead whale fall migration westward through the Beaufort Sea. Therefore, anticipated impacts of in-ice activities would be anticipated to be lower than those described for open-water surveys. However, using icebreaker vessels could cause avoidance and displacement of marine mammals over a larger radius (NMFS 2016f).

4.1.5. Changes in Communication or "Masking"

Masking is defined as the reduction in an animal's ability to detect relevant sounds in the presence of other sounds (NRC 2003b). It is one of the most pervasive effects of a general increase in background noise on most vertebrates, including marine mammals. This acoustic interference occurs when the signal and masking noise have similar frequencies and overlap in time and space (Richardson *et al.* 1995). Oil and gas activities might affect U.S. Arctic or Cook Inlet marine mammal behavior and habitat through masking by acoustically limiting the "communication space" of marine mammals due to increased noise levels. The communication space is defined by Clark *et al.* (2009) as "space over which an individual animal can be heard by other conspecifics, or a listening animal can hear sounds from other conspecifics." As a function of a marine mammal's hearing sensitivity, ambient noise SL, and animal distance from the source, masking may interfere with marine mammal communications (*e.g.*, a call to another whale might be masked by an icebreaker operating at a certain distance away) (Clark *et al.* 2009). Masking can effectively limit the "hearing habitat" of whales.

For example, masking of marine mammal communication calls would likely occur absent mitigation measures. The potential effects of noise can be identified by determining the areas or zones of influence over which particular effects might occur. Richardson *et al.* (1995) identified four concentric zones based on decreasing size of the affected area and increasing intensity of the signal. The largest zone includes audibility, followed by responsiveness, then masking, and finally the zone of hearing loss, discomfort, or injury. The geographic area and extent of the population over which effects would be felt (especially considering the distances over which some marine mammals communicate) would likely increase with multiple activities occurring simultaneously or consecutively in specific areas where human activities that produce underwater noise may be concentrated. Potential long-term effects from repeated disturbance, displacement, or habitat disruption, particularly on long-lived species such as the bowhead whale, are unknown. It is not currently possible to predict whether behavioral responses to anthropogenic noise have resulted in population-level effects for marine mammals.

In addition to a reduction in communication efficiency due to masking, bowhead whale vocalizations in the presence of anthropogenic noise may cease altogether (Blackwell *et al.* 2015; Blackwell *et al.* 2021). These authors speculated that at some noise level, behavioral context dependent, an animal may stop trying to compensate with louder sounds or sounds at an alternative frequency and cease to vocalize until acoustic conditions change. As noted above, the impact of this change in behavior to an animal or a population cannot be predicted at this time with available information.

4.1.6. Habituation to Disturbance

Bejder *et al.* (2009) discussed the general definition of "habituation" as a lack of response by a wild, free-ranging animal to a stimulus or stimuli. Rankin *et al.* (2009) further described habituation as:

> *…a behavioral response decrement that results from repeated stimulation and that does not involve sensory adaptation/sensory fatigue or motor fatigue. Traditionally, habituation has been distinguished from sensory adaptation and motor fatigue by the process of dishabituation; however, this distinction can also be made by demonstrating stimulus specificity (the response still occurs to other stimuli) or frequency-dependent spontaneous recovery (more rapid recovery following stimulation delivered at a high frequency than to stimulation delivered at a lower frequency).*

Sensory systems adapt to repeated occurrences of a signal not associated with physical discomfort or overt social stress through habituation (Richardson *et al.* 1995; NRC 2003b). Marine mammals show habituation to many signals that initially cause an overt reaction. The occurrence of habituation in marine mammals is generally identified by observing the changes in the response of animals of the same species in the same area, over time (Richardson *et al.* 1995).

Conversely, some research indicates that animals may go through a process referred to as "spontaneous recovery" after being exposed to a stimulus they have become habituated to. For example, (Blackwell *et al.* 2004b) noted that during impact pipe-driving at Northstar in June and July 2000, more than 55 hours of observations, 23 observed seals exhibited little or no reaction to any industrial noise except approaching Bell 212 helicopters. Ringed seals swam in open water near the island throughout construction activities and as close as 46 m from the pipe-driving operation. Based on current audiometric data for seals, these sounds are expected to be audible to less than 3 km underwater and at least 0.5 km in air. Most likely, the seals around Northstar Island were habituated to industrial sounds (Blackwell *et al.* 2004b). Under certain conditions, animals may tolerate a stimulus they might otherwise avoid if the benefits in terms of feeding, mating, migrating to traditional habitat, or other factors outweigh the negative aspects of the stimulus (Funk *et al.* 2010).

4.2. Physiological Effects

4.2.1. Noise-Induced Impairment and Threshold Shifts (TS)

TS is defined as an elevated hearing threshold for a given frequency, which may occur when marine mammals are exposed to intense underwater sound. If hearing thresholds return to pre-exposure levels, it is referred to as a TTS. A PTS occurs if hearing thresholds do not return to pre-exposure levels. The term compound threshold shift (CTS) refers to some combination of PTS and TTS (Finneran and Branstetter 2013) though is less used in a regulatory context. If TS occurs, sounds underwater for that frequency must be louder (*i.e.*, an increase in dB) for an animal to detect and recognize them. Specifically, while changes in hearing sensitivity rarely affect the entire frequency range marine mammals hear, it may affect specific frequencies which may be important to marine mammals for certain biological functions. Thus, when assessing the potential impact of an underwater noise on a marine mammal hearing group, it is important to know the frequencies of noises marine mammals may be exposed to in order to determine the potential effects on hearing. Marine mammal TTS data are based on a limited number of individual animals (Finneran 2015).

A report by (Nachtigall *et al.* 2003) described results from a behavioral study at the Hawaii Institute of Marine Biology to assess TTS in Atlantic bottlenose dolphins (*Tursiops 65rillsite*). Bottlenose dolphins were exposed to fatiguing low-frequency octave band noise and a behavioral threshold was reported for a 7.5-kHz tone (from a range of stimulus 4 to 11 kHz). The fatiguing stimulus was played once per week, and was gradually increased in time (up to 55 minutes) and intensity to 179 dB re 1μPa. Measured TTS averaged 11 dB and recovery was examined 360, 180, 90, and 45 minutes following exposure and was essentially complete within 45 minutes (NRC 2003b).

In addition to the Atlantic bottlenose dolphin tests, studies were sponsored by the U.S. Office of Naval Research, Sea Mammal Research Company, Russian Academie of Sciences, and Fjord and Baelt (Finneran 2015). While the exposure environments (ocean versus tanks), types of sounds (continuous versus intermittent), and species varied across these studies, they do provide some insight about TTS in selected marine mammals. It should be noted, however, that most tests of TTS in marine mammals have involved only a few individual animals. Thus, a key limitation to these studies is the ability to determine inter-individual variation. For example, TTS in two dolphins exposed to 16-second, 3-kHz tones was similar; however, differences were reported for TTS for harbor seals as well as belugas exposed to octave or half-octave noise bands (as reported in Finneran (2015).

The 2013 BiOp for oil and gas activities in the U.S. Arctic (NMFS 2013c) noted that:

> *…acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift (PTS), temporary threshold shift (TTS), and compound threshold shift (CTS) (Ward et al. 1998; Yost 2007). When permanent loss of hearing sensitivity, or PTS, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary because hair cell damage does not accompany TTS and losses in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks.*

As of 2006, in a BiOp for oil and gas leasing in the U.S. Arctic, NMFS cited Kastak *et al.* (2005) summarizing that the variables associated with various sound exposures must be taken into consideration including pressure, energy, and exposure levels because noise in the marine environment is sporadic and interrupted. In many cases, there are insufficient data to evaluate total energy exposure of a marine mammal to a given sound source (NMFS 2006d).

NMFS maintained this perspective in 2013 in acknowledging there are several variables that affect the potential loss in hearing sensitivity including level, duration, spectral content, and temporal patter of exposure as well as the sensitivity of individual animals and species. Whether TSs in marine mammal hearing is common is uncertain (NMFS 2013c). NMFS does not expect that every animal exposed to this level of sound would experience TTS, especially from periodic sounds that move through an area such as oil and gas exploration activities (NMFS 2016f).

NMFS (2013c) stated:

> *…data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals that experience permanent, temporary, or compound threshold shifts.*

Southall *et al.* (2019b) evaluated conclusions reported in Southall *et al.* (2007) in light of subsequent findings and proposed revised noise exposure criteria to predict the onset of auditory effects in marine mammals. Estimated audiograms, weighting functions, and underwater noise exposure criteria for TTS and PTS are reported for all marine mammal species, as well as other marine species. For continuous noise sources, exposure criteria are given in frequency weighted SELs. SEL and SPL criteria are reported for impulse noise. The authors noted that these criteria should be considered with regard to relevant caveats, recommended research, and with the expectation of subsequent revision. Further, eight discrete hearing groups of marine mammals were identified, including the group that includes the bowhead whale (*i.e.*, low-frequency cetaceans). Parameters for estimated audiograms are reported for each group (Table 4-3). TTS and PTS onset thresholds are also reported for each group for non-impulsive and impulsive (Table 4-4) noise. An extensive list of research recommendations that address specific information needs are also presented in Southall *et al.* (2019b), along with a comprehensive update of literature cited since Southall *et al.* (2007).

Table 4-4. Summary of PTS Onset Thresholds for Underwater Noise Based on Marine Mammal Hearing Groups

Hearing Group	PTS Onset Thresholds (Received Level)[1]		
	Impulsive (Peak, L_{pk}, flat)	Impulsive (cumulative weighted, LE, 24h)	Non-impulsive (cumulative weighted, LE, 24h)
Low-Frequency (LF) Cetaceans	219 dB	183 dB	199 dB
Mid-frequency (MF) Cetaceans	230 dB	185 dB	198 dB
High-frequency (HF) Cetaceans	202 dB	155 dB	173 dB
Phocid pinnipeds (PW) (underwater)	218 dB	185 dB	201 dB
Otariid pinnipeds (OW) (underwater)	232 dB	203 dB	219 dB

Source: NMFS (2018f)
[1] Dual metric thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak SPL thresholds associated with impulsive sounds, these thresholds are recommended for consideration. These thresholds are for underwater noise; there are separate TTS thresholds for in air noise.
Note: Peak SPL ($L_{pk,0\text{-}pk}$) has a reference value of 1 μPa, and weighted cSEL($L_{E,p}$) has a reference value of 1μPa^{2}s. In this table, thresholds are abbreviated to be more reflective of International Organization for Standardization standards. The subscript "flat" is being included to indicate peak sound pressure are flat weighted or unweighted within the generalized hearing range of marine mammals (*i.e.*, 7 Hz to 160 kHz). The subscript associated with cSEL thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The weighted cSEL thresholds could be exceeded in a multitude of ways (*i.e.*, varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these thresholds will be exceeded.

From NMFS (2013c):

> *Kastelien et al. (2012) exposed two harbor seals to a continuous octave-band of white noise centered at 4 kHz at three main received sound pressure levels (124, 136, and 148 dB re 1 µPa m) at up to six durations (7.5, 15, 30, 60, 120, and 240 min). Hearing thresholds were determined before and after exposure. Maximum TTS (1–4 min after 120 min exposure to 148 dB re 1 lPa) was 10 dB. Recovery occurred within ~60 min. Statistically significant TTSs (>2.5 dB) began to occur at 136 SPL, 60 min) and 148 SPL, 15min. The exposure SPLs used in Kastelien et al. (2012) were of the same order of magnitude as those used by Kastak et al. (2005; fatiguing noise at 80 and 95 dB sensation level). Kastak et al. (2005) found a 6 dB TTS at a SEL of 183 dB re 1 µPa2 s (SPL: 152 dB re 1 µPa; duration: 25 min) for a harbor seal.*

As reported in NMFS (2019b), TTS data only exist for four cetaceans and five pinnipeds, only a few of which occur in the U.S. Arctic or Cook Inlet including beluga whale, harbor porpoise, harbor seal and California sea lion. TTS was not observed in trained spotted or ringed seals exposed to impulsive sounds at level believed to induce TTS onset (Reichmuth *et al.* 2016, as cited in NMFS 2019b). Harbor porpoise and harbor seals generally have lower TTS onset than other pinnipeds.

Acoustic thresholds for Pacific walrus (*Odobenus rosmarus*) have been based on research published by Kastelein *et al.* (2002) and Reichmuth *et al.* (2020). As the 2016 USFWS Pacific Walrus IHA for Quintillion states, Pacific walruses may experience TTS when exposed to underwater SPLs greater than 180 dB. Continuous or repeated exposure to levels between 160 and 180 dB may also cause TTS while exposures above 160 dB are more likely to result in behavioral responses than lower-level exposures.

Available research indicates TTS in pinnipeds was evident from exposures ranging from 152-174 dB (183-206 dB SEL) (Kastak *et al.* 2005). Considering walruses may travel up to 30 km per day, extended exposures to high level of sound are unlikely (Jay *et al.* 2010). USFWS concluded that due to a lack of evidence, using the 120-dB NOAA threshold to define acoustic harassment of walruses is not supported (USFWS 2016d).

Sea otters are managed by the USFWS under the ESA and MMPA. Broad sea otter SPL rms thresholds for harassment determination have not yet been set (BOEM 2016). However, in an incidental take permit, the USFWS (2014d) used 160 dB re 1µPa @ 1 m threshold for behavioral harassment (Level B harassment under the MMPA) , and 190 dB re 1µPa @ 1 m for exposures that would cause injury (Level A harassment). Detailed definitions of level A and Level B harassment are provided in Section 5.1

4.2.2. Non-Auditory Effects or Stress

Long-term exposure to underwater noise may increase the occurrence of pathological stress (NRC 2003b). Stress in and of itself is not necessarily adverse. As Moberg (2000) described, all life forms have evolved mechanisms to cope with stress. The threat is the ‘stressor’. If an animal’s well-being is threatened, then the animal experiences ‘distress’. Simply using cortisol or other hormones as a measure of an animal’s stress (or ‘distress’) is difficult to interpret considering that hormones are also excreted during mating or other life activities that do not necessarily equate to a life-threatening circumstance. Thus, a critical question when considering how stress may affect marine mammals is what the biological cost of the stress is. For example, does the stress result in: diversion away from biological functions (*i.e.*, maintaining immune competence); reproduction; or growth? These are important considerations when evaluating the potential effects of oil and gas activities on marine mammals in the Beaufort and Chukchi seas and Cook Inlet.

4.3. Mortality

4.3.1. Vessel Strike or Interaction with Vessels

Schoeman *et al.* (2020) reviewed global records of ship strikes with marine mammals. Most publications on the topic discuss collisions between large whales and large vessels; however, smaller marine mammals may also be at risk of collision. NMFS has provided guidance on mitigation measures to avoid ship strike (NMFS 2021), including reduced vessel speeds, avoiding groups of marine mammals, or following deep-water routes among other measures (see Chapter 6). The increase in vessel traffic in the U.S. Arctic is likely to affect the vulnerability of marine mammal populations to ship strike while oil and gas activities, given the mitigation measures that are implemented, would likely remain a relatively low risk for ship strike.

As described in Schoeman *et al.* (2020), identifying areas or transit routes that may pose higher risk of interaction between vessels and marine mammals, and then avoiding those areas, is paramount for reducing risk. In a review of records of human-caused mortality of Alaska marine mammals from 2013-2017, Delean *et al.* (2020) determined that 28 out of 481 serious injuries or mortalities were due to ship strike. Burek Huntington *et al.* (2021) found that 8% of sea otter fatalities in Alaska over the period 2002-2012 were due to trauma. None of these cases in Delean *et al.* (2020) or Burek Huntington *et al.* (2021) were attributed oil and gas activities.

4.3.2. Crushing During Ice Road and Trail Construction, Maintenance, and Use

The 2020 final rule for sea ice roads, trails, and pads associated with oil and gas activities along the Beaufort Sea coast includes the potential for serious injury/mortality if an animal is crushed by construction machinery or a vehicle while in its subnivean lair (NMFS 2020c). The rule acknowledges that in 1998, one ringed seal mortality was documented during a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998). However, based on a review of literature and monitoring reports from Alaska North Slope projects, the likelihood of this occurring is extremely low given mitigation measures to prevent such an occurrence (see Chapter 6).

4.3.3. Entanglement

Delean *et al.* (2020) reviewed cases of human-caused mortality of marine mammals in Alaska for the period 2013 – 2017. Seven hundred and ninety-one of the 922 interactions were categorized as either mortality, serious injury, removal from the population or were prorated to reflect the likelihood of serious injury. Cause of death from entanglement or entrapment was most common (n=589). The majority of deaths from this source were from fishing gear (n=295) and marine debris (n=182).

In previously published BiOps and recent Incidental Take Authorizations (ITA) in Alaska, the impacts and likelihood of entanglement were dismissed as too remote to warrant scrutiny (USFWS 2003, 2012; NMFS 2015f). Furthermore, the avoidance marine mammals and fish typically extend toward seismic surveys, and the use of weighted and semi-rigid lines in seismic surveys further minimizes entanglement risks. By avoiding areas in the vicinity of seismic surveys, marine mammals and fish should not encounter node lines where they could potentially be affected. Semi-rigid lines linking end nodes to buoys would be incapable of flexing to the extent that a marine mammal, fish, or bird could become entangled with it. For these reasons, entanglement from seismic surveys is considered to be highly unlikely and not reasonably foreseeable (BOEM 2016).

4.4. Habitat Alteration

Oil and gas exploration (including seismic studies) and development (including construction) activities can alter habitat important for marine mammals in the Chukchi and Beaufort seas and Cook Inlet. Marine mammal habitat may be altered by: disturbance of sea ice from icebreaking, disturbance of benthic sediments during drilling, and contamination of the marine environment from oil spills, discharge of drilling muds, and other waste streams from ships and support facilities (NMFS 2016f).

Open-water habitat is not typically directly lost due to oil and gas activities. In the U.S. Arctic, barge landings, seawater treatment plants, and gravel islands are constructed in shallow waters on or close to shore (BLM 2020a). Chukchi and Beaufort sea whale habitat would not be expected to be directly removed or altered by oil and gas activities because open-water habitat is not directly impacted (BLM 2020a). In Cook Inlet, offshore platforms would not be expected to directly alter open-water habitat. However, open-water habitats used for migrating and feeding whales in both the U.S. Arctic and Cook Inlet may experience changes in the soundscape (see Section 4.1.2) that constitutes direct habitat loss (BOEM 2018, as cited in BLM 2020a).

Marine mammal habitat could be altered indirectly by disturbing the substrate where prey for some marine mammals reside (see Section 4.4.2), by contamination to sediments and the water column (see Section 4.4.3), or by waste streams, oil spills, or effluent (see Section 4.5 and 4.6). Marine mammals may avoid contaminated or otherwise altered habitats (see Section 4.1.4), resulting in spatial or temporal exclusion from preferred habitats. In addition, marine mammal prey can become contaminated due to discharges, spills, or leaks (see Section 4.6.2).

4.4.1. Spatial or Temporal Exclusion from or Reduction in Habitat

As described in Section 4.1, noise from oil and gas activities can cause behavioral disturbance and auditory impairment in cetaceans, pinnipeds, and polar bears. Such auditory disturbance to feeding, resting, or migrating marine mammals could cause them to leave areas of exploration and development activity and avoid those areas in the future, effectively reducing their available habitat (BLM 2020a).

Vessel presence and noise have the potential to disturb and displace whales from transit routes within the Chukchi and Beaufort seas, between Dutch Harbor and the Chukchi and Beaufort seas, or areas within Cook Inlet, causing temporary, short-term loss of use of habitat (*i.e.*, minutes required for vessels to pass) (BLM 2020a). Belugas and mysticetes whales, can show strong avoidance of moving vessels (BLM 2020a). However, USFWS' LOC concurred vessel movements in the marine transit route near Dutch Harbor would have a discountable impact at most on sea otters and sea otter critical habitat (USFWS 2015b).

During ice covered months, disturbance from on-ice seismic surveys or ice-breaking activities would be more limited than during ice-free months because fewer marine mammal species are present in the Arctic during that time although pinnipeds, primarily ringed seals, could be impacted given their use of nearshore ice. Most whales, however, are generally further south during the winter months. Therefore, increased noise from icebreaking activities may present concerns for pinnipeds and potentially a limited number of whales (NMFS 2010c).

Habitat alteration and avoidance could also occur from changes to water quality, such as from accidental spills or discharges from facilities or vessels. Effluents, such as brine discharged from seawater treatment plants, would impact local marine water quality, chemistry, and temperature, potentially making conditions unsuitable for marine mammals in the immediate vicinity of the discharge (see Section 4.6).

Polar bears and seals would experience direct behavioral effects from disturbance caused by human activities and noise associated with ice road and barge transportation (vehicle passage and noise), dredging or screeding for marine barge docks and gravel island construction, human activities at camps, and oil spill response planning and drills (BLM 2020a). Seals could be displaced by ice road and ice pad construction in areas typically used for denning (NMFS 2020d). Disturbance and localized displacement could occur during seasonal movements by polar bears in Chukchi and Beaufort seas and areas onshore. The net direction of movement by maternal females leaving terrestrial denning areas with young cubs is toward the coast, potentially requiring them to cross roads and pipelines during the development and production phases, although the number of such encounters likely would be small, as maternal dens tend to be concentrated near the coast (BLM 2020a). The greatest likelihood for bears to encounter oil- and gas-related infrastructure and activities is along the coast during the open-water season (mainly July–October), as bears move along the coast and congregate near whale-bone piles left by subsistence hunters. Any facilities constructed within 8.05 km of the Beaufort coast are located in polar bear critical habitat (see Section 7.8.3).

Although marine mammals show overt reactions to noise from industrial activities, individuals or groups may become habituated and continue to use their selected habitats if the noise does not result in physical injury, discomfort, or excessive social stress (NRC 2003a; BLM 2020b). Williams *et al.* (2006) concluded that ringed seals continued to use sea ice exposed to anthropogenic noise, vibration, and surface alteration related to offshore Northstar activities during the winter to the end of the ice-covered season. Blackwell *et al.* (2004b) reported that some ringed seals appeared to exhibit some level of tolerance to industrial noise at Northstar and continued to use haulouts and lairs in the vicinity of the island.

Oil and gas development in terrestrial Arctic habitats must also be considered due to potential impacts on polar bears. As identified in the final rule listing the polar bear as a threatened species under the ESA, the decline of sea ice habitat due to changing climate is the primary threat to polar bears (73 FR 28211). However, on shore oil and gas developments can impact or remove polar bear denning habitat (BLM 2019, 2020a, b). For example, under the preferred alternative, the proposed Willow development would permanently impact a total of 2.5 km^2 of polar bear habitat as a result of gravel infrastructure. The impacted acreage includes 0.006 km^2 of terrestrial denning critical habitat, 0.003 km^2 of potential terrestrial denning habitat, and 2.5 km^2 of habitat (BLM 2019, 2020a, b). Most of the permanent habitat loss from the Willow project would be outside of the area most used by polar bears, and mitigation measures, such as identifying dens using visual and infrared methods and establishing 1.6-km buffer zones around identified dens, would further reduce impacts denning bears and habitat. Similarly, BLM (2020a) determined that:

> *Temporary loss or alteration of polar bear denning habitat would result primarily from the construction of ice roads and pads, which persist for one winter season. The effects of ice placement in potential denning habitat would be temporary until the ice road or pad thawed during spring melt, although annual reconstruction in the same location would result in perennial loss of use of the specific bank-habitat segment affected. Because ice placement would not affect the topographic characteristics that create the favorable denning conditions, no long-term effects on habitat suitability would be expected.*

4.4.2. Prey Disturbance or Mortality

Marine mammal prey species could be disturbed or suffer direct mortality from the construction of ice roads or the installation of islands, drilling platforms, barge landing sites, docks or pipelines (BOEM 2016; NMFS 2019e). A recent article by Hawkins *et al.* (2021) discussed the potential effects of particle motion from anthropogenic sounds on substrate and the fish and invertebrates that use that habitat. Relatively few studies have been conducted on the effects of vibration (*i.e.*, from sound) on substrate; thus, the authors admit there are limited data to understand how fish and invertebrates may be affected. Sources of vibration from oil and gas activities may include seismic, pile-driving, explosions, or dredging for example. Sound-detection organs vary greatly among species of fish and invertebrates. Therefore, it is likely that each species has a different sensitivity to these perturbations. Further studies are needed to better assess the behavioral implications when fish and invertebrates are exposed to vibrations from anthropogenic sources (Hawkins *et al.* 2021).

In many cases, construction of offshore or nearshore gravel fill facilities is planned for the winter months. For example, during the proposed Liberty Project, the winter placement of gravel fill for the island and pipeline installation would increase suspended sediment concentrations in the marine waters in the immediate vicinity of the construction sites and create a turbidity plume extending into nearby areas (BOEM 2018). During the open-water construction season, as compared to winter construction, decreased total dissolved solids concentrations are expected. The deposition of fill materials and excavation of the pipeline route would occur during winter when ringed seals and the occasional polar bear would be the only marine mammal species found in the vicinity of the Liberty Project. Generally, turbidity does not directly affect marine mammals, except through effects to their prey species. Sedimentation from the construction of the island and the pipelines would result in a short-term release of sediments into the water, which would be dispersed across a broad area (BOEM 2018).

Other sources of seafloor disturbance that could affect benthic and epibenthic prey items include placement of nodes during the 2D seismic survey, boring during geotechnical surveys, drilling wells, and maintenance activities on existing pipelines (BOEM 2016; NMFS 2019a). These activities may also disturb other marine mammal prey items, such as pelagic and demersal finfishes and shellfishes, temporarily displacing them from preferred habitat, due to turbidity, vibrations, and noise from construction (MMS 2003b). However, disturbance, displacement, or injury as a result of drilling or seismic activities in Cook Inlet would be slight to subpopulations of fisheries resources. It was not expected that the various effects to fisheries resources in total, would cause population-level changes in the Cook Inlet region (MMS 2003b).

Seafloor disturbance and scour also occur from bottom-founded anchors associated with exploratory drilling operations [U.S. Department of Interior (USDOI), BOEM, 2015d, as cited in BOEM 2016)]. In addition, the seafloor may be physically disturbed from the sedimentation from discharges, potentially resulting in mortality of the organisms living there (Lissner *et al*. 1991, as cited in BOEM 2016). Seafloor disturbance, turbidity, and discharge from routine oil and gas activities may impact marine mammal benthic prey species and potentially the fitness of marine mammals. The extent of habitat alteration to the surface of the seafloor is a product of the volume and physical nature of materials (*e.g.*, mud, sand, cobblestone) that are displaced by the activities (NMFS 2015d, as cited in BOEM 2016).

Turbidity may affect the distribution and diversity of prey species including fish as well as the ability of marine mammals to locate prey in the immediate area of the drilling activity (as cited in BOEM 2016). The main impacts from drilling discharges would be temporary turbidity in the water column and localized alteration of the benthic environment around individual well sites (BOEM 2016). The discharge of drilling fluids and cuttings during drilling activities is unlikely to have large-scale effects on marine mammals, either directly through contact with marine mammals or indirectly by affecting their prey, because the effects would be restricted primarily to the areas immediately surrounding the rillsite. The settling of drilling fluid and cutting discharge would result in physical disturbance of habitats by smothering of benthic areas/species as well as the disturbance of pelagic species (Tetra Tech, Inc. 2012, as cited in BOEM 2016). Because the food supply for marine mammals consists of benthic and pelagic species, this could have a localized impact on their food supply. Impacts to marine mammal food sources from the discharge of drilling fluid and cuttings likely would be limited to a localized area and would not be substantial at a regional level (Tetra Tech, Inc. 2012, as cited in BOEM 2016).

The deposition of suspended material downstream of disturbances would cause the temporary loss of local benthic communities by smothering from deposition of sediment. Recovery time for substrate disturbances ranges from a few days or months to decades depending on the type and frequency of the disturbance as well as the type of organisms inhabiting the substrate (Lissner *et al*. 1991, as cited in BOEM 2016). The disturbance of these surfaces and their effects are further defined by the density of particles and the residence time of the water column as well as the area and depth of coverage of the benthic surface by displaced materials (NMFS 2015d, as cited in BOEM 2016). Effects may include the temporary disruption of pelagic habitat from turbidity caused by suspended material (NMFS 2015d, as cited in BLM 2020a). Disturbance, displacement, or injury as a result of drilling or seismic activities would be slight to subpopulations of fisheries resources.

In summary, aspects of oil and gas exploration and development have the potential to cause seafloor disturbance, increased turbidity, and discharges that may impact marine mammal benthic prey species. However, long-term, appreciable adverse impacts on benthic populations would not be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts to benthic or epibenthic prey that might occur as a result of oil and gas activities would be small compared to the naturally occurring high reproductive and mortality rates of benthic organisms (BOEM 2015b, as cited in NMFS 2019f). In addition, disturbed areas, depending on substrate types, community composition, and ocean current speed and direction, would begin the process of recolonization soon after the benthic disturbance ends (Conlan and Kvitek 2005, BOEM 2015a, as cited in NMFS 2019f). Seafloor disturbance from anchor handling activities would fill in through natural movement of sediment over time (NMFS 2019f). Amphipods, copepods, shrimp, nematodes, and polychaetes are among the first to recolonize, taking generally less than a year for establishment in new locations (Trannum *et al*. 2011, as cited in NMFS 2019f).

4.4.3. Contamination of Habitat

Contamination of marine mammal habitat in the U.S. Arctic and Cook Inlet could occur from authorized discharges related to oil and gas activities, or from accidental spills and leaks. Authorized discharges from oil and gas activities include drilling fluids and cuttings, deck drainage, sanitary and domestic waste, desalination unit brine, cooling water, fire control system test water, bilge and ballast water, and other miscellaneous discharges (NMFS 2019f). Other discharges that could occur during exploration drilling include blowout preventer (BOP) fluids, boiler blowdown discharges, excess cement slurry, several fluids used in subsea production, and uncontaminated freshwater and saltwater (USDOI, BOEM, 2012a, as cited in BOEM 2016). Water used for hydrotesting may be discharged during construction and commissioning of oil and gas pipelines (BOEM 2016).

Oil and gas production facilities on the Alaska North Slope use injection Class 1 and Class 2 wells to dispose of wastewater, produced water, spent fluids, and chemicals and other effluents, as approved by the U.S. Environmental Protect Agency (USEPA), Alaska Oil & Gas Association, or Alaska Department of Environmental Conservation (ADEC). Injection of wastewater reduces or eliminates potential impacts to marine and terrestrial habitats because the wastewater is injected deep underground into zones isolated from surface water and drinking water sources (U.S. Army Corps of Engineers(USACE 2018). All other discharges to the marine environment from oil and gas facilities are regulated through the Alaska Pollutant Discharge Elimination System (APDES) permitting process, and marine mammals are not expected to be adversely impacted by exposure to pollutants discharged in compliance with permit requirements (NMFS 2010b, EPA 2015, as cited in NMFS 2019f). If drilling discharges were released into the marine environment, the spatial extent of the release would be relatively small relative to marine mammal habitat and prey. Such discharges are expected to remain local as a result of rapid deposition and dilution, which would limit potential exposure (if toxic contaminants are present in discharges) to an extremely small proportion of the habitat or the prey base available to marine mammals; thus, population-level effects would be negligible.

Permitted discharged drilling fluids can be water-based fluids (WBFs) or synthetic-based fluids (SBFs) (BOEM 2016). In shallow environments, WBFs disperse rapidly in the water column and particulates quickly descend to the seafloor immediately after discharge, causing periodic minor increases in turbidity (Neff, 2010, as cited in BOEM 2016); in deeper water, fluids discharged at the sea surface are dispersed over a wider area (Neff, 1987, as cited in BOEM 2016). When discharged at the sea surface in the absence of swift bottom currents, SBF-wetted cuttings typically settle close to the discharge point affecting sediments and benthic invertebrates close by (Neff, McKelvie, and Ayers, 2000; Continental Shelf Associates, Inc., 2006; all as cited in BOEM 2016).

Spills and accidental releases of oil, fuel, or waste streams are not planned activities and are unpredictable in cause, location, size, time, duration, and material type (Robertson *et al.* 2013; Robertson and Campbell 2020a, b); . The effects of oil on marine habitats are based on the chemical composition of the spilled oil (NMFS 2019e). The composition of crude oil determines its behavior in the marine environment (Geraci and St. Aubin 1990a, as cited in NMFS 2019e). Weathering (*e.g.*, spreading, evaporating, dispersing, emulsifying, degrading, oxidizing, dissolution) and aging processes can alter the chemical and physical characteristics of crude oil (Figure 4-2). The environment in which a spill occurs, such as the water surface or subsurface, spring ice overflow, summer open-water, winter under ice, winter on ice, or winter broken ice, will affect how the spill behaves. In ice-covered waters, the weathering processes shown in Figure 4-2 occur, but the sea ice and cold temperatures can change the rates and relative importance of these processes (Payne *et al*. 1991, NRC 2014; both as cited in NMFS 2019e). In open water, oil released at or near the water surface will immediately begin to spread, or drift horizontally in an elongated shape driven by wind and surface water currents (Elliott *et al*. 1986, as cited in NMFS (2019e). If released below the water, oil will travel through the water column before it forms an oil slick at the surface. The rate of spreading is positively associated with increased temperature and wave action (Geraci and St. Aubin 1990a, as cited in NMFS 2019e). Oil spills in the cooler waters are expected to spread less and remain thicker than in temperate waters due to increased, viscosity of oil in colder temperatures (NRC 2014, as cited in NMFS 2019e). In increasing ice conditions spilled oil would be bound up in the ice, pumped to the surface by wind/wave action, or encapsulated in pack ice. In spring, the unweathered oil would melt out of the ice at different rates and locations.

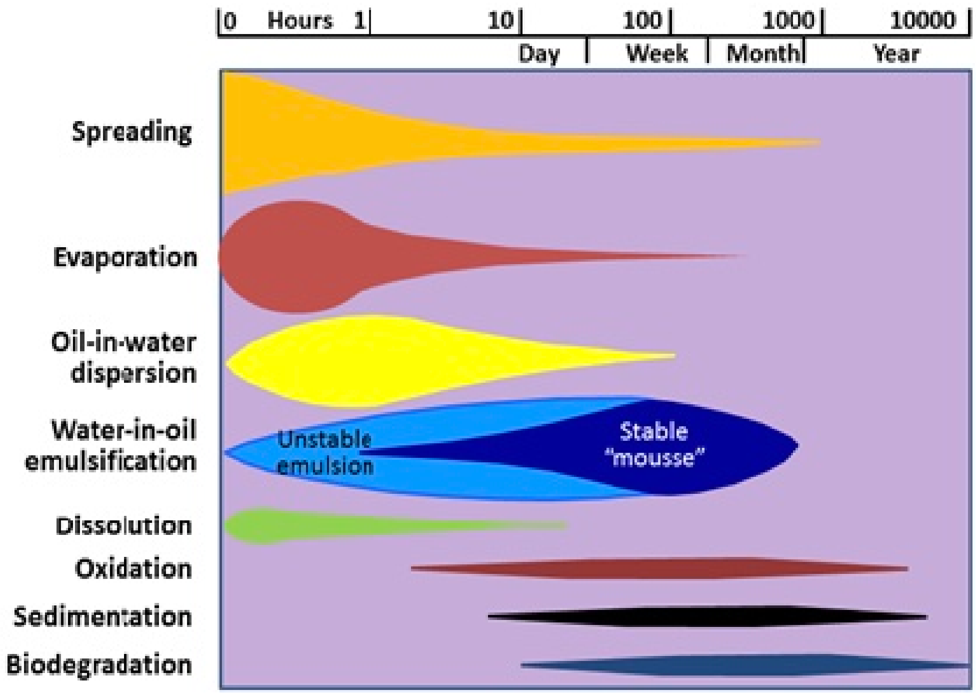

Figure 4-2. Oil Slick Weathering Processes Over Time

Source: Brandvik *et al*. (2010), as cited in NMFS 2019e)

Barging operations that support exploration, such as vessel refueling, are the most likely way a small spill of petroleum products could occur (NMFS 2019d). These types of spills typically involve relatively small volumes of refined oil products that would most likely volatize or weather away within hours to a couple days if they could not be contained or recovered. Habitat would not be severely affected.

In general, while considered unlikely, a large oil spill (greater than or equal to 1,000 barrels [bbl]) in the U.S. Arctic or Cook Inlet, especially during seasons where ice-infested waters occur, could adversely impact habitat quality for marine mammals in the vicinity of the spill. Section 4.6 provides additional details related to the impacts of a large oil spill on marine mammal populations in the U.S. Arctic or Cook Inlet.

4.5. Waste Streams (Trash)

Oil and gas activities generate solid waste consisting of food, sewage sludge, and other nonhazardous burnable and unburnable wastes (BLM 2020a). Solid wastes are separated and stored in large trash receptacles or approved containers at each site or on each drill ship until they can be incinerated or transported to an approved landfill. Burnable wastes are often incinerated on land, which temporarily affects air quality (BLM 2020a). Activities could also generate hazardous waste that would be handled and disposed of according to local, state, and federal regulations.

Offshore operations generate trash comprising paper, plastic, wood, glass, metal, and other materials (BOEM 2016). Most trash is associated with galley operations. Occasionally, personal items, such as hardhats and personal flotation devices, are accidentally lost overboard. The discharge of trash and debris is prohibited (33 CFR §§ 151.51 through 151.77) unless it is passed through a comminutor (a machine that breaks up solids) and can pass through a 25-millimeter mesh screen. Discharge of plastic is prohibited regardless of size. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste under a Waste Management Plan. USCG and USEPA regulations require operators to become proactive in avoiding accidental loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. In addition, over the last several years, companies operating offshore have developed and implemented trash and debris reduction and improved handling practices that have reduced accidental loss of trash and debris (BOEM 2016). Impacts to marine mammal habitat from trash associated with oil and gas activities would be minor.

4.5.1. Attraction to Facilities

Other than polar bears and walruses, marine mammals are not likely to be attracted to oil and gas-related activities or facilities (BLM 2020a). Polar bears are curious and opportunistic hunters; they frequently approach and investigate human activity (Stirling 1988; Truett 1993, as cited in BLM 2020a). Walruses have been known to approach coastal structures and vessels, possibly to seek a resting area or haulout. For example, in 2007, a female and a subadult walrus were observed hauled-out on the Endicott Causeway (81 FR 52289). Proximity to humans poses risks of injury and mortality for both polar bears and humans and may necessitate nonlethal take through deterrence and hazing or, on rare occasions, lethal take to defend human life (Stenhouse *et al*. 1988; Truett 1993, Perham 2005, as cited in BLM 2020a); walruses are at risk of injury but do not generally pose a risk to humans working at oil and gas facilities.

Stirling (1988, as cited in BLM 2020a) reported that curious polar bears commonly approach offshore drilling rigs in the Beaufort Sea whenever sea ice had moved into the area but did not remain nearby for long, unless seals were present in the leads created by the rigs. Similar behavior has been observed at Northstar Island. In recent years, sightings of polar bears at industrial sites in the Beaufort Sea region have increased, consistent with the species' increasing use of coastal habitats (Schliebe *et al*. 2008; USFWS 2008b, as cited in BLM 2020a and USFWS 2016a).

Encounters between polar bears and humans in the U.S. Arctic are most likely to occur on and near the coastline, as bears move through in late summer and fall (August–October) and as maternal females search for den locations in autumn and early winter (October–November) and depart from dens with dependent cubs in late winter (March–April); however, the latter animals are the least likely to be attracted to industrial facilities, due to their greater sensitivity to disturbance (BLM 2020a).

4.6. Effluent and Contaminants (including Drilling and Operational Discharges, Large Oil Spills or Gas Releases)

This section describes the direct effects of effluent and contaminants on marine mammals and their prey. The types of discharges and contamination of habitat by authorized or accidental discharges is described in Section 4.4.3.

Accidental oil spill impacts and likelihood have been described in several risk analyses conducted by BOEM for small to very large accidental oil spills (BOEM 2015a, 2016, 2018; Michel 2020, 2021). In addition, the NOAA Office of Response and Restoration webpage[11] describes how oil harms marine flora and fauna including links to specific literature and resources. The primary potential effects to marine mammals from accidental oil spills include: 1) fouling of individuals (including fur and baleen), 2) ingestion/inhalation of oil, 3) habitat/prey degradation, and 4) disruption of migration. Disruption of other essential behaviors, such as breeding, communication, and feeding, may also occur (BOEM 2017b, as cited in NMFS 2019e).

11 https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/how-oil-harms-animals-and-plants.html; Accessed November 1, 2021.

4.6.1. Mortality, Serious Injury, or Illness

If a large oil spill were to occur, marine mammals and their habitats could be adversely impacted. Marine mammals could experience adverse effects from contact with hydrocarbons, through the following routes of exposure (BOEM 2016):

- Inhalation of liquid and gaseous toxic components of crude oil and gas
- Ingestion of oil or contaminated prey
- Fouling of baleen in mysticetes, and fur or sea otters, seals, and polar bears
- Oiling of skin, eyes, and conjunctive membranes causing corneal ulcers, conjunctivitis, swollen nictitating membranes, and abrasions.

Animals can be affected outside of a main spill area through oil transported by currents and oiled prey. The exposure to oil needs to be in sufficient quantity to produce adverse effects from either external oiling, internal absorption from ingestion of oil and prey, aspiration of oil, inhalation of volatile vapors in the air, or a combination (NMFS 2019d).

Toxic substances can impact animals in two ways. First, the acute toxicity caused by a major point source of a pollutant (such as an oil spill or hazardous waste) can lead to acute mortality or moribund animals exhibiting a variety of neurological, digestive, and reproductive problems (NMFS 2019f). Second, toxic substances can impair animal populations through complex biochemical pathways that suppress immune functions and disrupt endocrine balances, causing poor growth, development, reproduction, and reduced fitness. Ingestion of hydrocarbons can irritate and destroy epithelial cells in the stomach and intestine of marine mammals, affecting motility, digestion, and absorption, often resulting in death or reproductive failure (Geraci and St. Aubin 1990, as cited in NMFS 2019f). Direct ingestion of oil, ingestion of contaminated prey, or inhalation of volatile hydrocarbons transfers toxins to body fluids and tissues causing effects that may lead to death, as suspected in dead gray and harbor seals found with oil in their stomachs (Engelhardt 1982, Geraci and St. Aubin 1990, Frost *et al*. 1994, Spraker *et al*. 1994, Jenssen 1996, Jenssen *et al*. 1996, all cited in NMFS 2019f). Additionally, harbor seals observed immediately after oiling appeared lethargic and disoriented, which may be attributed to lesions observed in the thalamus of the brain (Spraker *et al*. 1994, as cited in NMFS 2019f).

The greatest threat to cetaceans is likely to be from inhaling volatile toxic hydrocarbon fractions of fresh oil, which can damage the respiratory system (Hansen 1985, Neff 1990, as cited in NMFS 2019f), cause neurological disorders or liver damage (Geraci and St. Aubin 1990, as cited in NMFS 2019f), have anesthetic effects (Neff 1990, as cited in NMFS 2019f), and cause death (Geraci and St. Aubin 1990, as cited in NMFS 2019f). However, for small spills or leaks of refined fuel, toxic fumes would rapidly dissipate into the atmosphere thereby limiting potential exposure of marine mammals to prolonged inhalation of toxic fumes.

Research has shown that while cetaceans are capable of detecting oil, they do not seem to be able to avoid it (NMFS 2019f). For example, during the spill of Bunker C and No. 2 fuel oil from the Regal Sword, researchers saw humpback and fin whales, and a whale tentatively identified as a right whale, surfacing and even feeding in or near an oil slick off Cape Cod, Massachusetts (Geraci and St. Aubin 1990, as cited in NMFS 2019f). NMFS (2019e) anticipates that if a very large oil spill were to occur in the U.S. Arctic, a large number of whales could be directly impacted. The duration of impacts could range from temporary (such as skin irritations or short-term displacement) to permanent (*e.g.*, endocrine impairment or reduced reproduction) and would depend on the length of exposure and means of exposure, such as whether oil was directly ingested, the quantity ingested, and whether ingestion was indirect through prey consumption. Displacement from feeding areas impacted by the spill due to the presence of oil and increased vessel activity could result in impacts of higher magnitude (NMFS 2019e).

The disappearances (and probable deaths) of killer whales and the deaths of large numbers of gray whales coincided with the *Exxon Valdez* oil spill and with observations of members of both species in oil (Matkin *et al*. 2008, as cited in BOEM 2016). It is anticipated that if other odontocetes (*e.g.*, Cook Inlet beluga) or baleen whales (*e.g.*, humpback or fin whales) were exposed to a large spill in Cook Inlet, mortalities may also occur depending on the time of year, location of spill, and extent of the spill. Cook Inlet beluga whales may be severely impacted at the individual and population level by a very large spill event (BOEM 2016).

Should seals come into contact with spilled oil, they may experience a range of effects, from temporary behavioral impacts to injury and death (Geraci 2012, as cited in NMFS 2019d). Seals can potentially ingest spilled product while feeding, inhale their volatile components, or experience problems from direct contact. Exposure to fresh oil may result in the inhalation of volatile fractions of the oil, with possible injury to the lungs and central nervous system. Seals that contact low-molecular-weight fractions of petroleum hydrocarbons on the water surface, can suffer temporary damage of the mucous membranes and eyes or epidermis (Walsh *et al*. 1974, Hansen 1985, Geraci and St. Aubin 1990, all cited in NMFS 2019f). Contact with crude oil can result in corneal ulcers and abrasions, conjunctivitis, and swollen nictitating membranes (Geraci and Smith 1976a, Geraci and Smith 1976b, all cited in NMFS 2019f). Crude oil immersion studies resulted in 100% mortality in captive ringed seals (Geraci and Smith 1976b, as cited in NMFS 2019f). Ice seals in the wild would be able to use ice as a resting/escape platform; or they may be able to detect and avoid spilled oil during the open-water period (Geraci and St. Aubin 1990, as cited in NMFS 2019f).

Researchers have suggested that ice seal pups may be particularly vulnerable to oil on their dense lanugo coat (Geraci and St. Aubin 1990, Jenssen 1996, as cited in NMFS 2019f). Bearded seal pups exhibit some prenatal molting, but they are generally not fully molted at birth, and thus would be particularly prone to physical impacts of contacting oil. Adults, juveniles, and weaned young of the year ice seals rely on blubber for insulation and are not as reliant on their coats for insulation; effects on thermoregulation are expected to be minimal. Due to an acute sense of smell and good vision, both ringed and bearded seals likely could detect and avoid spills on the water's surface (St. Aubin 1990, as cited in NMFS 2019f). Further, bearded seals can depurate some hydrocarbons from their bodies (BLM 2019).

Oiled polar bears would likely ingest oil during grooming efforts and would be susceptible to hypothermia. Heavily oiled bears would not survive unless capture and cleaning efforts were successful (Ortisland *et al*. 1981, as cited in BOEM 2018).

'Where the collection of oil at the surface is not feasible or practical, efforts to haze animals to avoid or leave an area provides some mitigation potential. In 2017, NOAA published the "Arctic Marine Mammal Disaster Response Guidelines" (AMMDRG) (Wright *et al.* 2017), building upon national guidelines pursuant to statutory obligations under the Oil Pollution Act of 1990 (33 U.S.C. § 2701 et seq.) and the National Contingency Plan (40 CFR § 300 et seq.). National Contingency Plan guidelines require preparedness planning, notification and communication of a release, and response operation at the scene of a discharge. The AMMDRG provides, among other things, measures to be taken in the event a discharge occurs in the U.S. Arctic. For example, specific procedures for deterrence and hazing are provided; however, they must be conducted under the authority and oversight of trustee agencies (NMFS or USFWS). As such, these activities are considered "harassment" that could result in "take" of marine mammals under the MMPA (Wright *et al.* 2017).

Of all marine mammals, sea otters are most likely to be detrimentally affected by contact with oil (USFWS 2014b). Oiling of their pelts drastically reduces the insulative value of the pelage, and consequently, it is believed that sea otters can survive low levels of oil contamination (<10% of body surface), but that greater levels (>25%) will lead to death (Costa and Kooyman 1981, Siniff *et al.* 1982, as cited in USFWS 2014b). As described in Section 7.9.2, vulnerability of sea otters to oiling was demonstrated by the 1989 *Exxon Valdez* oil spill in Prince William Sound (USFWS 2014c, b). Estimates of mortality for the Prince William Sound area vary from 750 otters (Garshelis 1997, as cited in USFWS 2014b) to 2,650 otters (Garrott *et al.*

1993, as cited in USFWS 2014b). Statewide, 3,905 sea otters were estimated to have died in Alaska as a result of the spill (DeGange *et al*. 1994; (USFWS 2014b).

In summary, while marine mammals may suffer mortality, or show irritation, annoyance, or distress from oil, generally their need to remain in an area for food, shelter, or other biological requirements overrides any avoidance behaviors to oil (Vos *et al*. 2003, as cited in NMFS 2019e). In addition, depending on the location of a spill, highly populated areas would be more susceptible than sparsely populated areas. Animals can be affected outside of a main spill area through oil transported by currents and oiled prey (Figure 4-3). The exposure to oil needs to be in sufficient quantity to produce adverse effects from either external oiling, and internal absorption or from ingestion of oil and prey, aspiration of oil, inhalation of volatile vapors in the air, or a combination of the above (NMFS 2019e).

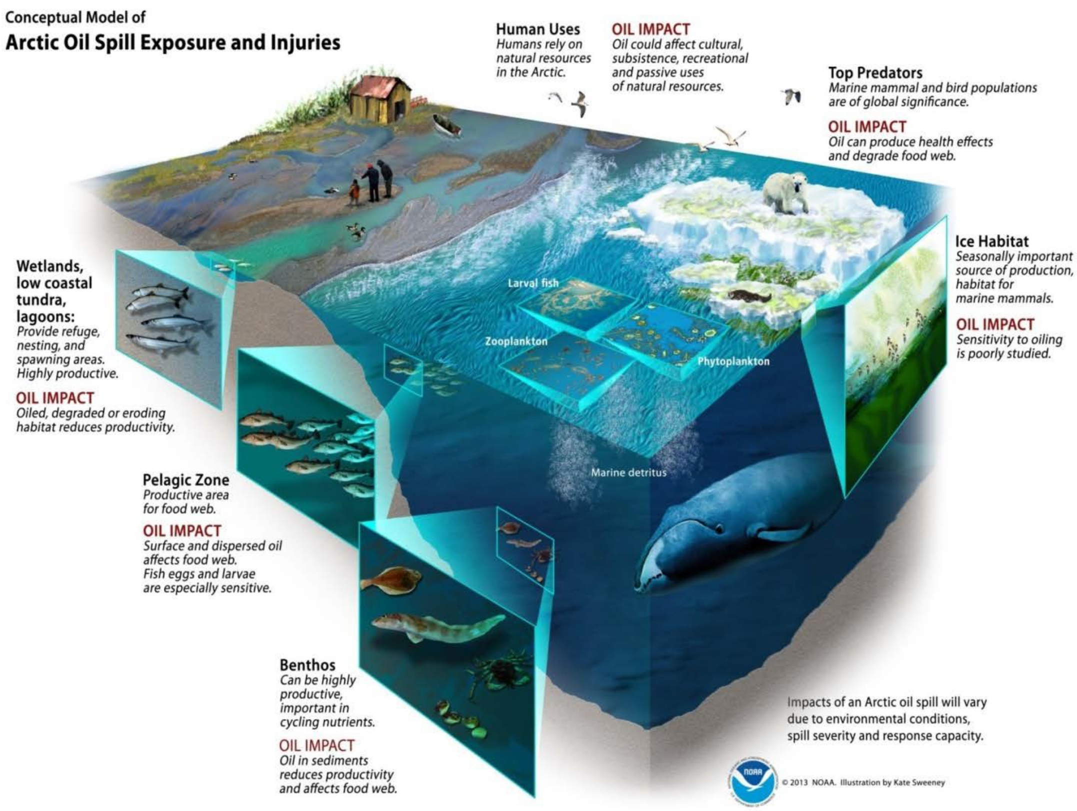

Figure 4-3. Conceptual Model of U.S. Arctic Oil Spill Impacts

Source: NMFS (2019e)

4.6.2. Contamination or Mortality of Prey

Alteration of habitat by turbidity or increased sedimentation and resulting potential impacts to prey of marine mammals is described in Section 4.4.2. Prey also can be impacted by the authorized and unauthorized effluent and discharges described in Section 4.4.3. As discussed in that section, authorized discharges that meet permit requirements are not expected to impact marine mammals or their prey. However, spills and accidental releases of oil, fuel, or waste streams could impact marine mammal prey species in the Chukchi and Beaufort seas or Cook Inlet.

Primary prey species for marine mammals, such as beluga whales in Cook Inlet, include zooplankton swimming in the open estuarine and marine waters, benthic animals in the estuarine zone and on the shallow sea bottom, and smaller fish categorized as forage fish (MMS 2003b). Consuming oiled zooplankton has been identified as a likely avenue of oil exposure in fish in the *Exxon Valdez* oil spill (Peterson 2001, as cited in MMS 2003b), providing an additional path for contamination as marine mammals consume the contaminated fish. Figure 4-3, although focused on U.S. Arctic environments, depicts potential food web impacts applicable in Cook Inlet. NMFS (2019f) found that exposure to contaminated prey multiple times over the long lifetime of sea lions could increase contamination of tissues through accumulation. MMS (2003b) estimated a 19% chance that one or more spills greater than or equal to 1,000 bbl could occur during depuration and development on leases in Cook Inlet. The likely effects of a large oil spill in Cook Inlet would include the mortality of adult forage fishes, and lethal and sublethal effects to millions of eggs and juvenile stages of finfishes and shellfishes. A large spill impacting subtidal and intertidal habitat areas would have the greatest impact to fisheries resources, chiefly resulting in lethal and sublethal effects on forage fish and intertidal species potentially important to marine mammals. Impacts could affect subpopulations lasting multiple generations (MMS 2003b).

In the Arctic, the prey of polar bears, ice seals, bowhead whales, beluga whales, and walrus could be contaminated by oil if a large spill were to occur. Polar bears scavenge animal carcasses, but it is unclear whether they would avoid contaminated carcasses (BOEM 2018). In addition, polar bears are known to be attracted to petroleum products and can be expected to actively investigate oil spills; they also can consume foods contaminated with petroleum products (Derocher and Stirling 1991; St. Aubin 1990, as cited in BOEM 2018). A small oil spill would be localized and would not permanently affect fish and invertebrate populations that are whale and ice seal prey (NMFS 2019d). The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available throughout the range of marine mammal species in the vicinity of the spill (NMFS 2018b). As described in Section 4.6.1, cetaceans may be able to detect and avoid spilled oil during the open-water periods and may thus avoid ingesting prey contaminated by a large or very large oil spill in the Arctic. If an oil spill in the Arctic were to cause extensive mortality within a high latitude amphipod (bowhead whale prey) population, a marked decrease in secondary production could ensue in some areas (Highsmith and Coyle 1992, as cited in NMFS 2019e), thereby affecting bowhead whales. Sublethal contamination of amphipods could also affect bowhead whales; exposure to contaminated prey multiple times over the long lifetime of these whales could contaminate whale tissues through accumulation of toxins (NMFS 2019e).

4.7. Types of Cumulative Effects That Could Occur from Multiple Oil and Gas Activities

Cumulative impacts, the "incremental impacts of actions when added to other past, present and reasonably foreseeable actions", can result from individually minor, but collectively significant, actions taking place over a period of time (EPA 1999). In principle, cumulative effects are the combination of past, present, and reasonably foreseeable future actions and events with potential contributions. This section provides a summary of the types of cumulative effects on marine mammals that have the potential to occur as a result of oil and gas activities in the U.S. Arctic and Cook Inlet. Section 7.10 of Volume II provides a summary of what has been documented in literature with respect to cumulative effects on marine mammals in the U.S. Arctic and Cook Inlet.

Marine mammals exposed to oil and gas activities may simultaneously experience environmental change associated with climate change as well as other external factors that contribute to a cumulative effect. There are multiple factors to consider when evaluating potential cumulative effects on marine mammals. In addition, different examples and varying perspectives are provided in available literature which can make it challenging to draw definitive conclusions. Available information currently does not allow for accurate evaluations of how the impacts of global warming in the Arctic (*e.g.*, loss of sea ice) and ocean acidification over the next 50 years will impact the western Arctic stock of bowhead whales (Moore and Huntington 2008; Ashjian *et al.* 2010; Kovacs *et al.* 2010; IPCC 2014; Grebmeier *et al.* 2015; Moore and Stabeno 2015; Druckenmiller *et al.* 2018). However, a number of scenarios have been identified: 1) increased competition with other marine species that feed at the same trophic level, 2) increased predation pressure associated with loss of sea ice (Willoughby *et al.* 2020), and 3) change in the recurrence of oceanographic conditions in predictable locations conducive to marine mammal feeding. For example, Laidre *et al.* (2008) concluded that western Arctic bowhead whales would be moderately sensitive to climate change, based on an analysis of life history features. Ferrara (2017) concluded that bowhead whales would have low vulnerability to climate change. Thewissen and George (2021) speculated that the recent years where sea ice levels have been less than average have had above average zooplankton production, which has resulted in above average body condition in bowhead whales. Huntington (2009) noted that Arctic marine mammals over the next several decades will face threats from: 1) climate change, 2) environmental contaminants, 3) offshore oil and gas activities, 4) shipping, 5) hunting, and 6) commercial fisheries. The author concluded that climate change, oil and gas activities, and commercial fishing pose the most serious threat to populations of Arctic marine mammals. Further, the author commented that addressing the impacts of all six factors would be necessary to avoid future declines in marine mammal abundance in the Arctic. Moore (2016) reported that interspecific competition for prey between the five western Arctic species of baleen whales (including bowhead whales) and subarctic species is possible, although differences in migration timing and species-specific foraging behaviors will likely limit such effects. These are just a few examples of the types of cumulative effects that may occur. Please also see Section 7.10 for more specific information on cumulative effects in the U.S. Arctic on marine mammals.

5. Marine Mammal Regulatory Framework

As described in Section 2.2, marine mammals are protected under the MMPA and the ESA. In simple terms, the MMPA requires the determination of acceptable levels of interactions that may cause harm as a result of human activities while the ESA requires managers to evaluate potential effects of human activities on the viability or recovery of an ESA-listed species or its designated habitat. Federal actions such as issuing an MMPA incidental take authorization (*i.e.*, IHA or LOA) also triggers an environmental review under NEPA. Each of these three regulations have different purposes and requirements but all contribute to evaluating, managing, and monitoring potential impacts of oil and gas activities on marine mammals. In addition, subsistence hunting of whales is governed by the International Whaling Commission (IWC), established under the 1946 International Convention for the Regulation of Whaling (ICRW). Since 1982, overall catch limits have been set for stocks subject to aboriginal subsistence whaling such as bowhead whales. This chapter provides an overview of each regulation within the context of oil and gas activities in the U.S. Arctic and Cook Inlet.

5.1. Marine Mammal Protection Act

Under the MMPA (16 U.S.C. § 1371, 50 CFR Subpart 1), the "taking" of marine mammals, incidental or otherwise, without a permit or exemption is prohibited. The term, "take" under the MMPA, means:

> *…to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. 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].*

NMFS' implementing regulations for the MMPA are described in 50 CFR § 216, while the USFWS' implementing regulations for MMPA are in 50 CFR § 18.27.

Among the activities exempted from the MMPA's moratorium on the "take" of marine mammals is subsistence hunting of marine mammals by Alaska Natives (Section 101(b)). An exception to the MMPA moratorium on marine mammal takes is for the incidental, but not intentional, "taking" by U.S. citizens, while engaging in an activity (other than commercial fishing) of "small numbers"[12] of marine mammals (as stated in Section 101(a)(5)).

Incidental take is an "unintentional, but not unexpected, take" of a marine mammal. To obtain an exemption for incidental take from the MMPA's prohibition on taking marine mammals, a citizen must obtain an ITA under Section 101(a)(5)(A) or (D). An ITA shall be granted if NMFS "finds" or determines that the taking is of only small numbers of marine mammals of a species or stock, that the taking will result in no more

[12] The MMPA does not define small numbers and so, in practice, NMFS compares the number of individuals taken to the most appropriate estimation of abundance of the relevant species or stock in a determination of whether an authorization is limited to small numbers of marine mammals (48 FR 31220, July 7, 1983).

than a negligible[13] impact on the affected species or stock(s), and the taking will not have an unmitigable adverse impact[14] on the availability of the species or stock(s) for taking for subsistence uses.

NMFS, USFWS, and BOEM are required to analyze the environmental impacts associated with authorizing the take of marine mammals incidental to oil and gas exploration activities in the U.S. Beaufort and Chukchi seas using the best available science[15] and including impacts to marine mammals and the subsistence uses of these species. Such analyses must consider the effects associated with issuing ITAs for oil and gas activities including those described in Chapter 3.

The MMPA defines two levels of take by harassment: 1) An act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); and 2) harassment that has the potential to only 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). For this reason, there are two types of ITAs that can be issued by NMFS or USFWS: 1) an LOA under Section 101(a)(5)(A); and 2) an IHA under Section 101(a)(5)(D) of the MMPA.

In issuing MMPA authorizations, NMFS and USFWS must prescribe, where applicable, the following:

> *(I) permissible methods of taking by harassment pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for subsistence uses pursuant to subsection (b) of this section or section 1379 (f) of this title or pursuant to a cooperative agreement under section 1388 of this title,*
>
> *(II) the measures that the Secretary determines are necessary to ensure no unmitigable adverse impact on the availability of the species or stock for taking for subsistence uses pursuant to subsection (b) of this section or section 1379 (f) of this title or pursuant to a cooperative agreement under section 1388 of this title, and*
>
> *(III) requirements pertaining to the monitoring and reporting of such taking by harassment, including requirements for the independent peer review of proposed monitoring plans or other research proposals where the proposed activity may affect the availability of a species or stock for taking for subsistence uses pursuant to subsection (b) of this section or*

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[13] NMFS and USFWS have defined negligible impact as “an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival” (50 CFR § 216.103 and 50 CFR § 18.27, respectively). In addition to considering estimates of the number of marine mammals that might be ‘‘taken’’ through harassment, the agencies consider other factors, such as the likely nature of any responses (*e.g.*, intensity, duration), the context of any responses (*e.g.*, critical reproductive time or location, migration), as well as effects on habitat, and the likely effectiveness of the mitigation.

[14] NMFS and USFWS have defined “unmitigable adverse impact” in 50 CFR § 216.103 and 50 CFR § 18.27, respectively, as “an impact resulting from the specified activity: (1) That is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by: (i) Causing the marine mammals to abandon or avoid hunting areas; (ii) Directly displacing subsistence users; or (iii) Placing physical barriers between the marine mammals and the subsistence hunters; and (2) That cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.”

[15] NMFS’ implementing regulations 50 CFR § 216.102(a) and USFWS’ implementing regulations 50 CFR § 18.27(d)(ii).

section 1379 (f) of this title or pursuant to a cooperative agreement under section 1388 of this title.

5.1.1. MMPA Requirements for Mitigation, Monitoring and Reporting

Under the MMPA (50 CFR § 216.108), holders of an IHA or LOA issued for incidental take of marine mammals are required to cooperate with NMFS, USFWS, and other designated federal, state, or local agencies to monitor the impacts of their activity on marine mammals. For example, NMFS' instructions for a "complete and adequate" IHA application includes the following statement:

> *The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.*[16]

Further, Section 11 of an IHA or LOA application to NMFS must include measures that have a reasonable likelihood of accomplishing or contributing to one or more of the following goals:

- Avoiding or minimizing injury or death of marine mammals.
- Reducing the number, duration, or severity of marine mammal takes, especially in areas or times of biological importance (*e.g.*, feeding or reproductive areas) or to stocks of particular concern.
- Avoiding or minimizing adverse effects to marine mammal habitat, paying special attention to:
    - Food base;
    - Activities that block or limit passage to or from biologically important areas; and
    - Permanent destruction of habitat or temporary destruction/disturbance of habitat during a biologically important time.
- For monitoring directly related to mitigation, increasing the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation.

USFWS guidance on MMPA authorization requests as well as requirements for mitigation and monitoring refer to the requirements in the MMPA.[17] The MMPA states that a monitoring program must "*document the effects (including acoustical) on marine mammals and document or estimate the actual level of take.*" Monitoring plans are developed through coordination between project proponents and the regulator (*i.e.*, USFWS or NMFS) and may vary depending on the activity, location, time, and marine mammal species that may be incidentally harassed by the project.

Monitoring reports for an IHA issued by NMFS must be submitted to the regulator between 90 and 120 days of completion of the activity (50 CFR § 216.108). NMFS guidance for applicants seeking an authorization under the MMPA state that the application must include:

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

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[16] https://www.fisheries.noaa.gov/national/marine-mammal-protection/apply-incidental-take-authorization#section-11:-mitigation-measures-to-protect-marine-mammals-and-their-habitat; (Accessed August 26, 2021)

[17] https://www.fws.gov/r7/fisheries/mmm/itr.htm; (Accessed August 26, 2021)

> *other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.*

The MMPA implementing regulations (50 CFR § 216) state that monitoring reports for an IHA must include:

- Date(s) and type(s) of activity;
- Date(s) and location(s) of any activities related to monitoring the effects on marine mammals; and
- Results of monitoring activities, including an estimate of the actual level and type of take, species name and numbers of each species observed, direction of movement of species, and any observed changes or modifications in behavior.

5.1.2. Chronology of MMPA Authorizations

For the period 2000 through 2020, there have been nearly 100 MMPA rules or authorizations (*i.e.*, rules/LOAs or IHAs) for oil and gas activities in the U.S. Arctic or Cook Inlet. Figures 5-1 and 5-2 present a chronology of the MMPA authorizations in the U.S. Arctic or Cook Inlet, respectively, that have been completed since 2000. While Figures 5-1 and 5-2 may not be an all-inclusive list, they are a good representation of the number of authorizations for the period.

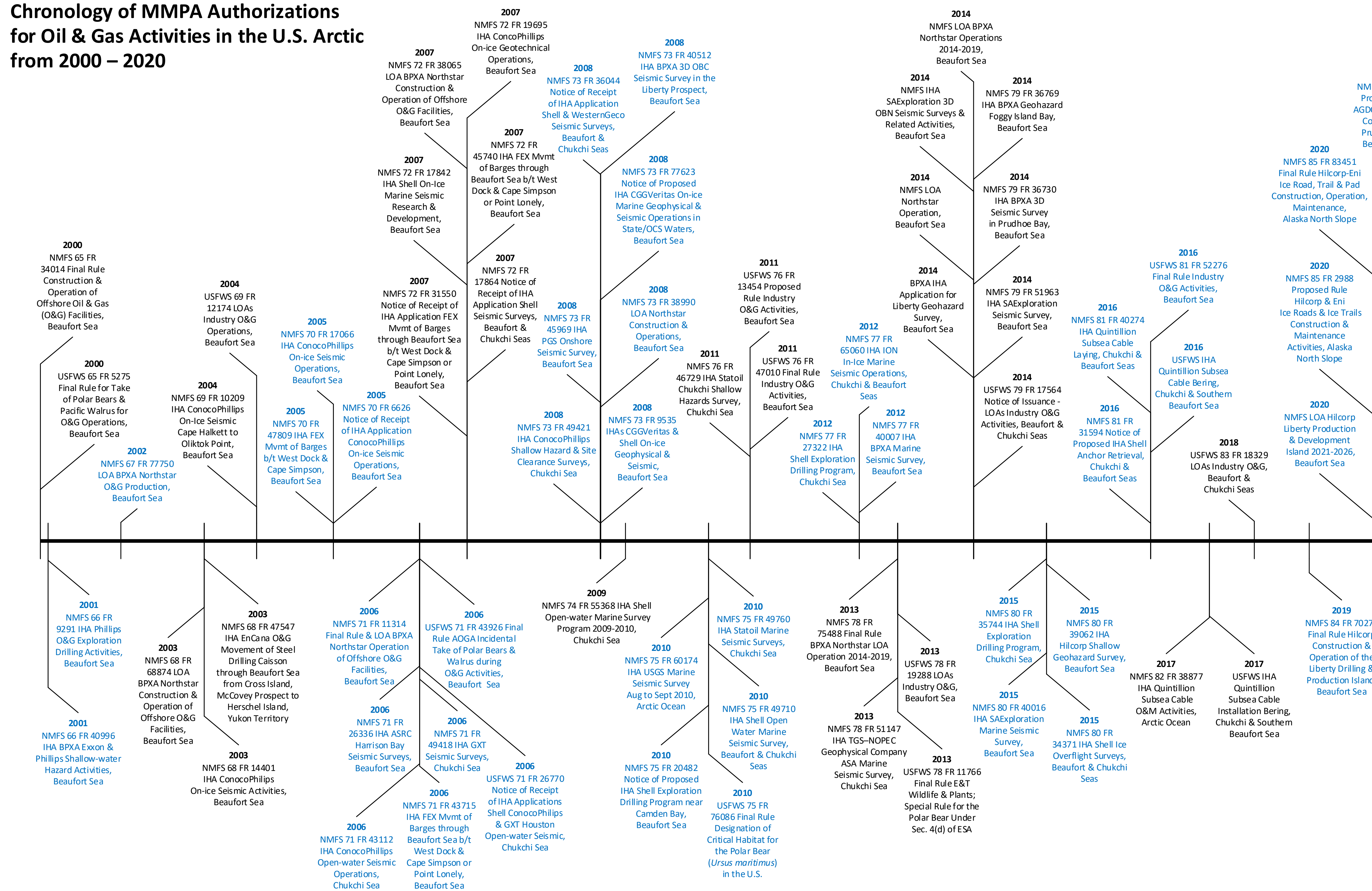

Figure 5-1. Chronology of MMPA Authorizations in the U.S. Arctic

Chronology of MMPA Authorizations for Oil & Gas Activities in Cook Inlet, Alaska from 2000 – 2020

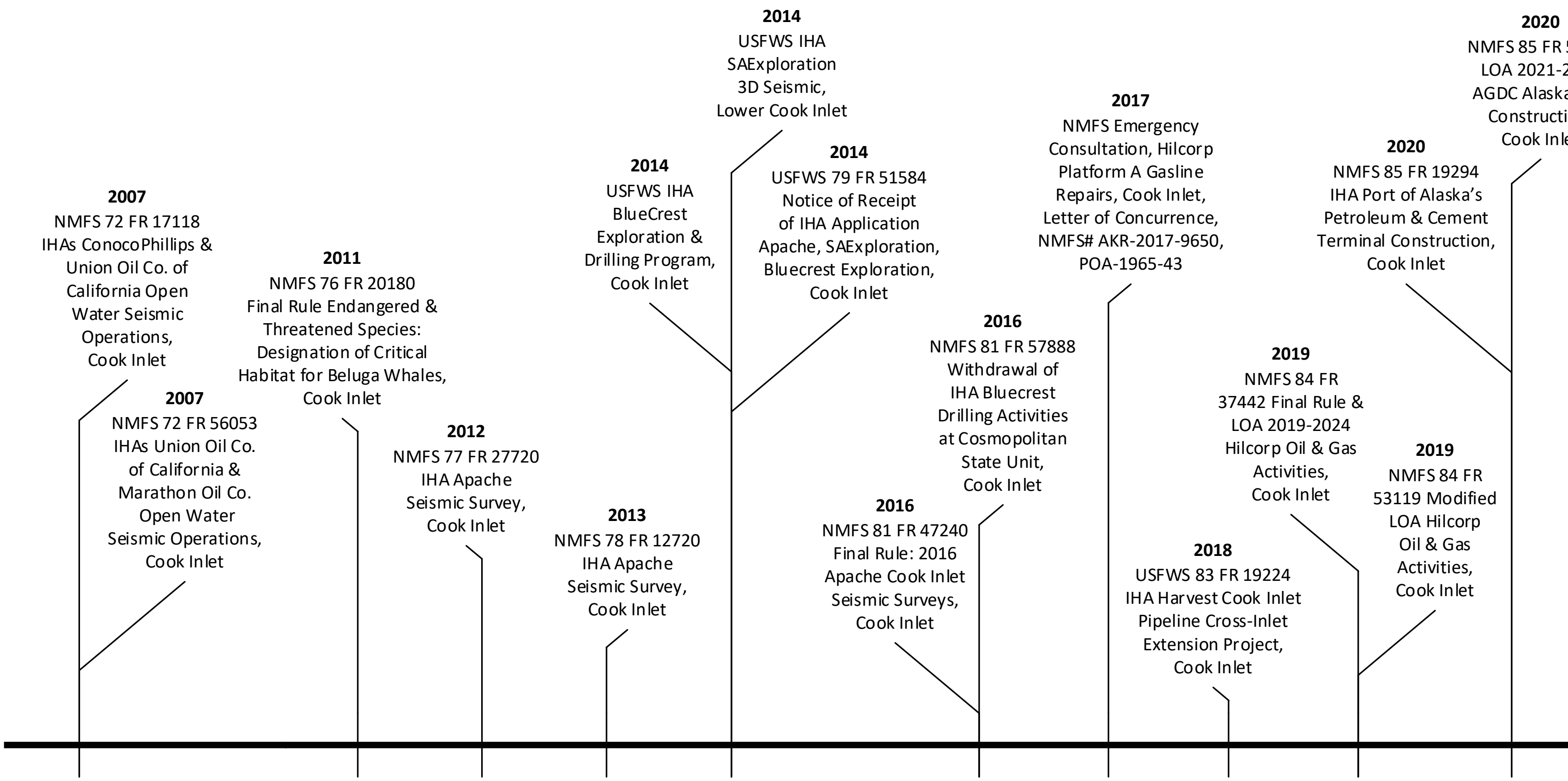

Figure 5-2. Chronology of MMPA Authorizations in Cook Inlet

5.2. Endangered Species Act

The ESA is designed to protect endangered and threatened fish, wildlife, and plant species and their ecosystems upon which they depend. The ESA prohibits the "take" of species listed as endangered by the USFWS or NMFS. Once listed, Section 9 (16 U.S.C. § 1538) of the ESA makes it unlawful for any person to "take" individuals of an endangered species and by regulations at 16 U.S.C. § 1538(a), threatened species. Section 9 identifies prohibited acts related to endangered species and prohibits all persons, including all federal, state, and local governments, from taking listed species of fish and wildlife, except as specified under provisions for exemption (16 U.S.C. §§1535(g)(2) and 1539).

Similar to the MMPA "take", under the ESA "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" to species listed as threatened or endangered in 16 U.S.C. § 1532(19). NMFS has not further defined "harass" under the ESA but interprets harass in a manner similar to the USFWS regulatory definition. NMFS has defined "harm" under the ESA to include significant habitat modification or degradation, which "actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering" (at 50 CFR § 222.102, NOAA Fisheries "Harm Rule"). Under this "harm rule" significant habitat modification that result in the impairment of a species' essential behavioral patterns may constitute a violation of the Section 9 take prohibition (50 CFR § 222.102). NMFS has not defined the term "harass" under the ESA.

Species listed as threatened may have the take prohibition applied to them by further regulations pursuant to Section 4 of the ESA.

5.2.1. Responsibilities under Section 7 of the ESA

Section 7 (16 U.S.C. § 1536) of the ESA states that all federal agencies:

> *…shall, in consultation with, and with the assistance of the Secretary of the Interior or Commerce (Secretary), ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species, which is determined by the Secretary to be critical.*

The ESA and MMPA intersect when either NMFS or USFWS issues an ITA (a federal action) that involves ESA-listed species. In other words, if USFWS or NMFS issue an IHA or LOA that involves ESA-listed species, then they must conduct Section 7 consultation.

When federal action agencies determine their proposed actions have "no effect" on any ESA-listed species or designated critical habitat neither the ESA nor the NMFS/USFWS joint consultation regulations mandate consultation. However, whenever a proposed federal action may affect threatened or endangered species or designated critical habitat, the ESA requires federal agencies to consult with NMFS or USFWS. The purpose of this consultation is to assist the federal agency in ensuring that its actions and the actions of any permit or license applicant are not likely to "jeopardize the continued existence" of a listed species, or "destroy or adversely modify" a species' designated critical habitat, as required by the ESA at 16 U.S.C. § 1536(a)(2).

If ESA-listed species are present within an action area, NMFS or USFWS must determine the potential effects of the action according to the following three categories.

- **No Effect**: The proposed action will have zero effect on the listed species or critical habitat.

- **May Affect but Not Likely to Adversely Affect**: The proposed action may affect the listed species or critical habitat, but the effects will be insignificant, discountable, or beneficial.
- **May Affect and Likely to Adversely Affect**: The proposed action may negatively and significantly affect the listed species or critical habitat.

If there will be no effect, Section 7 consultation is not required. A Biological Assessment prepared by the project proponent or action agency will provide NMFS or USFWS the necessary information to determine whether informal consultation or formal consultation is required. Informal consultation is conducted if adverse effects are not anticipated, whereas formal consultation is required if the activity may affect and is likely to adversely affect the species or critical habitat. If formal consultation is conducted, NMFS or USFWS will prepare a BiOp to present final determinations regarding potential effects on listed species. Formal consultations must be completed within 135 days of initiation—90 days for consultation, plus 45 days for coordination between the agencies, unless an extension is agreed upon by the agencies.

To facilitate the consultation process, USFWS provides tools through the Information, Planning and Consultation system to help agencies, applicants, and project proponents with the Section 7 process. More information is available online at: https://ecos.fws.gov/ipac.

BOEM follows an incremental two-step process in ESA consultations. The first step of the process is typically a programmatic consultation on the activities which most likely involve leasing/lease sales, geological and geophysical surveys, and exploration activities and production for a specific geographic area and the ESA-protected species and designated critical habitat found there. The second consultation step occurs for each site-specific development and production in the OCS. This step includes consultation on such exploratory activities as seismic surveys and exploratory drilling.

5.2.2. Expedited Section 7 Consultations

NMFS provides criteria[18] for when an expedited Section 7 consultation under the ESA is possible for routine, non-controversial actions that pose minimal threats to listed resources. The expedited process strives to minimize the time required for NMFS or USFWS to complete informal consultations that meet the following criteria:

- An adequate description of the proposed action, including mitigation measures.
- An adequate description of the action area.
- Identification of each ESA-listed species or designated critical habitat that may be affected by the action along with a reference to the most recent listing/designation notice in the Federal Register and any applicable species recovery plans.
- An adequate discussion of each potential effect on the ESA-listed species or essential features of designated critical habitat along with an adequate rationale why the effects would be discountable (extremely unlikely to occur), insignificant (too small to meaningfully measure or detect), or wholly beneficial.
- Certification that the action agency has used the best scientific and commercial data available.

[18] https://www.fisheries.noaa.gov/alaska/endangered-species-conservation/expedited-informal-consultation-process-alaska; (Accessed July 22, 2021)

The NMFS Alaska Region ESA Division webpage[19] provides guidance on developing a Marine Mammal Monitoring Plan, including a list of template protocols for pile-driving activities that can be adapted based on the nature of the activity. Minimum qualifications for protected species observers (PSOs) are also listed on this webpage.

5.2.3. Monitoring Requirements and Re-Initiating ESA Section 7 Consultation

Section 402.14(h)(B)(4) of the ESA specifies that a BiOp prepared during formal consultation must include:

- Reasonable and prudent measures to minimize impact(s), including those required under the MMPA; and
- Reporting requirements in accordance with 50 CFR §§ 13.45 and 18.27 for USFWS and 50 CFR §§ 216.105 and 222.301(h) for NMFS.

The federal agency must re-initiate consultation under Section 7(a)(1) of the ESA If:

- During the course of the action, the estimated amount or extent of incidental take is exceeded;
- New information reveals effects that were previously not considered;
- A species is newly listed or new critical habitat is designated; or
- Five years have passed since the enactment of Public Law 115-141 [March 23, 2018] or the date of the listing of a species or designation of critical habitat, whichever is later.

5.2.4. Chronology of Biological Opinions

For the period 2000 through 2020, there have been more than 60 BiOps and many LOCs prepared to evaluate the potential for oil and gas activities to affect ESA-listed species in the U.S. Arctic or Cook Inlet. Figures 5-3 and 5-4 present a chronology of BiOps and some LOCs in the U.S. Arctic or Cook Inlet, respectively, that have been completed since 2000. While Figures 5-3 and 5-4 may not be an all-inclusive list, they are a good representation of the number of consultations for the period.

[19] https://www.fisheries.noaa.gov/alaska/endangered-species-conservation/guidance-developing-marine-mammal-monitoring-plan; (Accessed July 22, 2021)

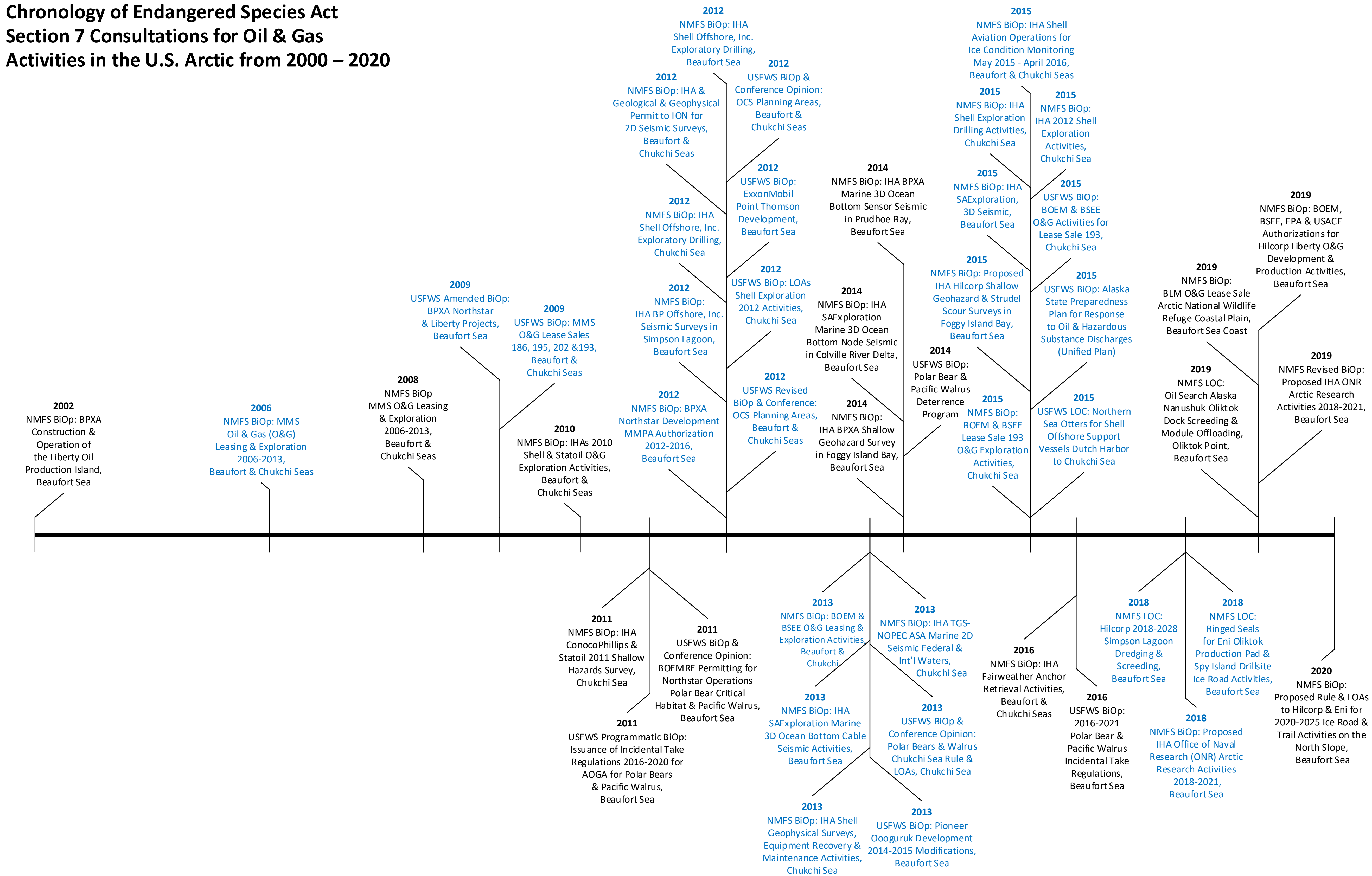

Figure 5-3. Chronology of ESA Consultations in the U.S. Arctic

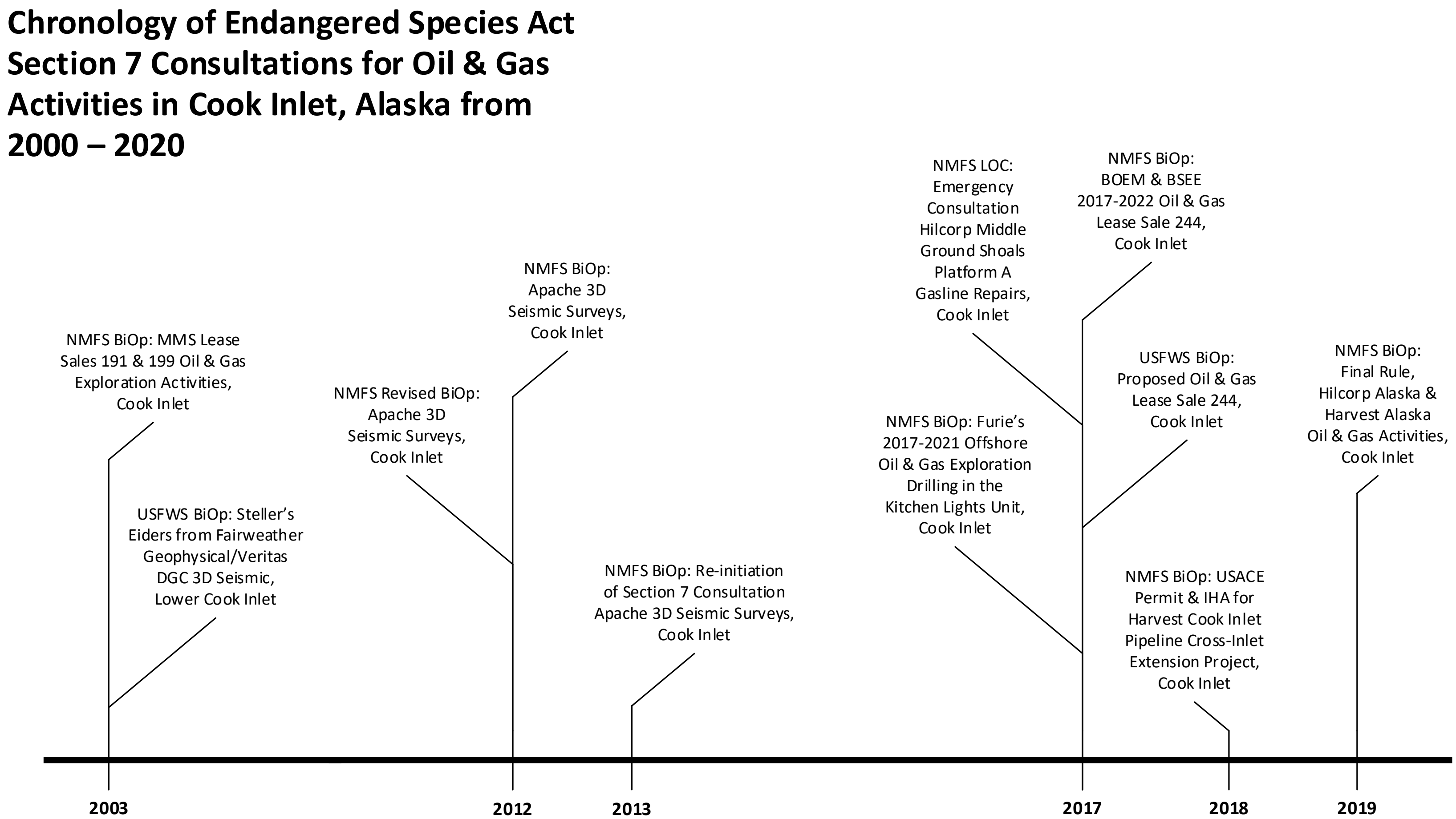

Figure 5-4. Chronology of ESA Consultations in Cook Inlet

5.3. National Environmental Policy Act

NEPA (42 U.S.C 4321 et seq.) was signed into law in 1970 and requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. The range of actions covered by NEPA within the context of this synthesis report may include:

- Issuing permits or authorizations (such as MMPA incidental take authorizations); or
- Oil and gas lease sales or land management actions.

In 1978, the U.S. Council on Environmental Quality (CEQ) issued regulations (40 CFR §§ 1500-1508) to implement NEPA. These regulations are binding to all federal agencies. In some cases, federal agencies may have unique NEPA procedures or guidance specific to the agency's jurisdiction, authority, or trust resources. There are three types of evaluations under NEPA including a CatEx, EA, or EIS. A CatEx covers activities that would not individually or cumulatively significantly affect the quality of the human environment (40 CFR § 1508.4). An EA is a concise evaluation of a proposed action compared against alternative actions to determine whether significant effects may occur. If no significant effects are expected, then the agency prepares a FONSI. If a proposed federal action does not fall within a designated CatEx or does not qualify for a FONSI, then an EIS is prepared. The EIS process ends with publication of a Record of Decision to record the agency's decision concerning the proposed action.

At several stages throughout the oil and gas development process, BOEM produces NEPA documents following the USDOI Department Manual Part 516. For example, BOEM's Office of Environmental Programs prepares NEPA documents for OCS oil and gas leasing programs, while regional offices prepare NEPA documents for specific lease sales or as required for exploration, development, and production. NOAA NMFS prepares NEPA documents following their internal guidance published in NOAA Administrative Order (NOA) 216-6A, while USFWS uses their own NEPA Reference Handbook as authorized in 505 FW 1.7 and 550 FW 1.

Large-scale or complex actions requiring an EIS may designate a "lead" agency to oversee the NEPA process. Other federal, state, and local agencies, and federally recognized tribes may join the process as "cooperating agencies" to help identify issues to be addressed, arrange data collection, analyze data, develop alternatives, evaluate alternatives, and carry out other tasks necessary during the NEPA process (43 CFR § 46.230). In addition, a federal agency may formally adopt another agency's NEPA document to promote efficiency in the environmental review process.[20]

Finally, NEPA implementing regulations (40 CFR § 1506.6) states that agencies shall make diligent efforts to involve the public in preparing and implementing their NEPA procedures. Furthermore, agencies must "assess and consider public comments both individually and collectively" (Title 40 CFR § 1503.4). Public comments provide valuable information and insight regarding the proposed action and resources or human communities that may be affected and are considered by the action agency before making any final decision.

5.4. International Convention for the Regulation of Whaling, Whaling Convention Act, and the Alaska Eskimo Whaling Commission

The International Convention for the Regulation of Whaling (ICRW), signed on December 2, 1946, is an international treaty intended to "provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry" (ICRW, 161 United Nations Treaty Series 72) (NMFS 2018c). The ICRW created the IWC, consisting of one commissioner from each government that signed the ICRW. It is responsible for establishing regulations for the management of protected and unprotected

[20] https://www.epa.gov/nepa/national-environmental-policy-act-review-process; (Accessed July 22, 2021)

species of large whales; open and close seasons and waters; size limits, time, methods and intensity of whaling; and specify gear, methods of measurement, catch returns, and other statistical and biological records and methods for inspection of whale stocks (NMFS 2018d). The IWC recognizes the distinction between aboriginal whaling and commercial whaling and has established provisions to allow subsistence whaling to continue even when commercial whaling of certain species is prohibited.

Subsistence hunting of the western Arctic stock of bowhead whale has been managed under provisions of the IWC since the mid-1970s. There are prohibitions on striking, taking, or killing calves or any whale accompanied by a calf. For bowhead whales, numeric catch limits are also in place including: 1) a limit on the number of whales landed; 2) a slightly higher limit on the number of whales that may be struck; and 3) carryover or carry-forward provisions for unused strikes. “Strike quota” refers to a limit on the number of whales that may be struck, considering that not all whales struck are landed due to harvest conditions and other factors. Strike quotas ensure an upper limit on total whale mortality for stewardship purposes (NMFS 2018d).

In September 2018, the IWC took action to provide increased flexibility for Alaska Native communities to conduct the subsistence hunt of bowhead whales. Specifically, the catch limits for bowheads were extended through 2025 and can be automatically renewed under specified circumstances. Up until this meeting, the potential existed for members of the IWC to block approval of catch limits for western Arctic bowhead whales based on political expedience. The threat of such actions in the past had created considerable angst regarding food security in Alaska communities dependent on a bowhead whale harvest. For all practical purposes, the threat of such actions has now been eliminated.

As an agent of the U.S. government, NMFS has a trust responsibility to Indian tribes to carry out mandates to protect tribal land, assets, and resources. In addition, NMFS has been delegated the authority by the U.S. Secretary of Commerce to administer and enforce whaling in the U.S., including issuance of regulations to carry out that authority under the Whaling Convention Act (WCA) (16 U.S.C. § 916) in accordance with the ICRW. In 1977, the Alaska Eskimo Whaling Commission (AEWC) was formed to represent the bowhead subsistence hunting communities of Alaska. NMFS and AEWC have a Cooperative Agreement to work together to: 1) protect the western Arctic population of bowhead whales; 2) promote scientific investigation of bowhead whales; and 3) effectuate the WCA, MMPA, and ESA, as these acts relate to the aboriginal subsistence hunt of bowhead whales (NMFS 2018c).

6. Types of Mitigation and Monitoring Measures Used in the U.S. Arctic and Cook Inlet

All marine oil and gas projects in the U.S. Arctic and Cook Inlet have required some form of mitigation and monitoring to reduce impacts on marine mammals. One of the benefits of this retrospective synthesis is that it assembles a comprehensive list of measures that have been implemented (Table 6-1). In addition, successful mitigation and monitoring measures have been aided by the contribution of Alaska Native traditional knowledge. Traditional knowledge can be defined as a body of evolving practical knowledge based on observations and personal experience of indigenous residents over an extensive time period. It can be described as information based on the experiences of a people passed down from generation to generation. It includes extensive understanding of environmental interrelationships and can provide a framework for determining how resources are used and shared. Importantly, mitigation and monitoring measures to reduce impacts of oil and gas have also considered or are based on traditional knowledge.

Table 6-1 lists mitigation and monitoring measures that have been used in Alaska offshore projects since the late 1990s. The table also provides information including relevant marine mammal species, types of oil and gas activities for which they were implemented, and selected citations describing or discussing the measure.

Early ADNR lease stipulations regarding marine mammal protection in the U.S. Arctic focused on: 1) seasonal drilling restrictions to protect the bowhead whale hunt; 2) avoidance of areas where polar bear denning was known to occur; and 3) avoidance of areas where spotted seal haul. Lease stipulations also required CAAs with marine mammal hunting associations (*e.g.*, AEWC). CAAs, which were initiated in 1986 (Levfevre 2013), are included in all Beaufort Sea lease sale stipulations and advisories from 2001 to 2019 (ADNR 2001a, 2002a, 2003a, 2007, 2008, 2010, 2013, 2014, 2015, 2016, 2019). The 2003 Beaufort lease sale stipulations stated specifically that the MMPA must be followed (ADNR 2003a) and in 2010, stipulations stated that the NMFS and USFWS requirements for ESA must be followed for bowhead whales and polar bears (ADNR 2010). There were no changes in lease stipulations related to marine mammals after 2010. The most recent lease stipulations for the Beaufort Sea are summarized in the final Finding of the Director (ADNR 2019).

Prior to 2004, there were no specific lease requirements to protect marine mammals in Cook Inlet; the 2001-2003 lease sale stipulations only included specific requirements for certain offshore areas deemed “sensitive” (ADNR 2001b, 2002b, 2003b). In 2004, lease sale stipulations for Cook Inlet leases specifically mention that ESA regulations must be followed for fin, sei, and Cook Inlet beluga whales and Steller sea lions, and that MMPA rules for authorizing takes must also be followed (ADNR 2004). Additionally, in 2004 ADNR added a Best Interest Finding for Cook Inlet belugas that put certain areas off limits for all oil and gas exploration and designated other areas for seasonal restrictions to protect beluga whales. In 2012, northern sea otters were added to the list of ESA species to be considered (ADNR 2012). No other changes regarding lease stipulations for marine mammals occurred after 2012. The most recent ADNR mitigation measures for Cook Inlet are summarized in the Final Finding of the Director (ADNR 2018).

Sections 6.1 through 6.14 describe, in alphabetical order, marine mammal mitigation measures undertaken in the Beaufort and Chukchi seas, Cook Inlet, and along the marine transit route, as applicable. Many of these mitigation measures are relatively standard for oil and gas activities and have become part of the requirements for MMPA authorizations, depending on the type of activity proposed. As described in Chapter 8, implementation of these mitigation measures has been shown to reduce the likelihood of adverse impacts to marine mammals that could result from oil and gas activities.

Table 6-1. Mitigation Measures

Measure	Brief Description	Region: Cook Inlet	Region: Chukchi Sea	Region: Beaufort Sea	Season: Marine Transit Route	Season: Ice-covered Conditions	Season: Open Water	Activity: Seismic Surveys (OBC/OBN)	Activity: Site Clearance[1]	Activity: Non-impulsive Vibroseis	Activity: Exploratory Drilling Noise	Activity: Development Drilling and Production	Activity: Anchor Management	Activity: Vessel Transit	Activity: Aircraft	Activity: Pile-Driving/Drilling	Activity: Dredging/Screeding	Activity: Gravel Placement (Fill)	Activity: Pipeline Installation (Trenching)	Activity: Pipeline Maintenance/Replacement[2]	Activity: Pile/Pipe Removal	Activity: Decommissioning, Abandonment, and Reclamation[3]	Selected Citations
Oilfield Exploration, Development, or Production																							
Acoustic Monitoring	Passive acoustic monitoring (PAM) using Autonomous Multichannel Acoustic Recorders (AMARs) or Directional Autonomous Seafloor Acoustic Recorders (DASARs).[4] Used in addition to visual monitoring. Also used to detect presence of marine mammals.	X[5]	X	X		X	X	X	X	X	X	X				X	X	X	X	X	X		Richardson and Williams (2001); Bureau of Ocean Energy Management, Regulation, and Enforcement [BOEMRE (2011); LGL Alaska Research Associates Inc. et al. (2014), LGL Ltd. and Marine Acoustics Inc. (2011); NMFS (2012j); NMFS (2016f); NMFS (2012k); SAExploration (2012); NMFS (2016c); NMFS (2016f); BOEM (2018); Castellote (2019); NMFS (2019c)
Acoustic Modeling (SSV)	Provide SSV data to establish safety zones and disturbance radii.	X	X	X		X	X	X	X	X	X	X	X			X	X	X	X	X	X		BOEMRE (2011); LGL Ltd. and Marine Acoustics Inc. (2011); BOEM (2012a); NMFS (2012k); BOEM (2014a); LGL Alaska Research Associates Inc. et al. (2014); NMFS (2016c); NMFS (2016f); BLM (2019); Castellote (2019); Castellote et al. (2019) BLM (2020b)
Aircraft Management	Altitudes, routes, behavior over animals in water or on haulouts.	X	X	X		X	X								X								(NMFS 2000); USFWS (2004); BOEMRE (2011); Shell (2011); NMFS (2012j); NMFS (2012k); USACE (2012); USFWS (2014a); NMFS (2015g); NMFS (2016f); USFWS (2016a); BOEM (2018); BLM (2019); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2019c); BLM (2020b)
Avoidance (Geospatial or Temporal)	Geospatial avoidance and Project scheduling;[6] timing and location of surveys; avoidance of annual subsistence hunts and locations. Also avoidance of ringed seal seals and lairs, and polar bear dens.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NMFS (2003a); NMFS (2004); NMFS (2006a); MMS (2007a); NMFS (2007a); NMFS (2007c); NMFS (2009); LGL Ltd. and Marine Acoustics Inc. (2011); Shell (2011); BOEM (2012a); NMFS (2012f); NMFS (2012j); NMFS (2012k); USACE (2012); NMFS (2013a) BOEM (2014a); BOEM (2015a) ; NMFS (2015b); NMFS (2015g); BOEM (2016); NMFS (2016c); NMFS (2016f); USFWS (2016a); BOEM (2017); BOEM (2018); NMFS (2018a); ; NMFS (2019c); NMFS (2019e); Hilcorp Alaska LLC and Harvest Pipeline (2019); BLM (2019, 2020b)
Biological Studies	Determine the extent and composition populations or habitats potentially affected.	X	X	X		X	X				X	X				X	X	X	X	X		X	MMS (2007a); BOEMRE (2011); USACE (2012); BOEM (2015a) ;NMFS (2015b); NMFS (2015g); BOEM (2015a); BOEM (2016); NMFS (2016f); BOEM (2017); USFWS (2017b); BOEM (2018); BLM (2019); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2019e); BLM (2020b)
Conflict Avoidance Agreements and Plans of Cooperation[7]	Incudes Exploration and Development Plans; public meetings[8] and providing communication centers and infrastructure during whale hunts or spill response.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NMFS (2009); NMFS (2010a); Shell (2011); NMFS (2012j); NMFS (2012k); NMFS (2013a); USACE (2012); BOEM (2015a); NMFS (2015b); NMFS (2015g); BOEM (2016); NMFS (2016c); BOEM (2017); BOEM (2018); BLM (2019); BLM (2020b)
Engineering Measures	Certification of all casing and cementing programs by a registered professional engineer; use of directional drilling; appropriate hydrocarbon transportation and storage; double-hulled vessels, blow-out restrictors, other spill prevention measures.		X	X							X	X											Shell (2011); BOEM (2015a); BOEM (2016); BOEM (2017); BOEM (2018)

		Region			Season			Activity for Which Measure Is Implemented															
Measure	**Brief Description**	**Cook Inlet**	**Chukchi Sea**	**Beaufort Sea**	**Marine Transit Route**	**Ice-covered Conditions**	**Open Water**	**Seismic Surveys (OBC/OBN)**	**Site Clearance[1]**	**Non-impulsive Vibroseis**	**Exploratory Drilling Noise**	**Development Drilling and Production**	**Anchor Management**	**Vessel Transit**	**Aircraft**	**Pile-Driving/Drilling**	**Dredging/Screeding**	**Gravel Placement (Fill)**	**Pipeline Installation (Trenching)**	**Pipeline Maintenance/Replacement[2]**	**Pile/Pipe Removal**	**Decommissioning. Abandonment, and Reclamation[3]**	**Selected Citations**
Exclusion Zones and Safety Zones	Acoustic modeling used to define ensonified areas and then Exclusion and Safety Zones.	X	X	X		X	X	X	X	X	X		X			X	X	X	X	X	X		NMFS (2006a); BOEMRE (2011); LGL Ltd. and Marine Acoustics Inc. (2011); Shell (2011); BOEM (2012a); SAExploration (2012); NMFS (2012j); NMFS (2012k); NMFS (2013a); BOEM (2014a); USFWS (2014e) NMFS (2016c); NMFS (2016f); BOEM (2018); Fairweather Science LLC (2018); Sitkiewicz *et al.* (2018); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2019c); (NMFS); NMFS (2020a)
Limit or Cease Operations when Visibility is Poor	Cease operations if unable to view entire safety zone.	X	X	X		X	X	X	X	X	X		X			X	X	X	X	X	X		(NMFS 2000); BOEM (2012a); NMFS (2010a) (NMFS 2013a) (BOEM 2014a); NMFS (2016c); NMFS (2016f); BOEM (2018); BLM (2019); NMFS (2019c); BLM (2020b); NMFS (2020a)
Monitoring Programs	Industry site-specific bowhead whale monitoring program.		X	X							X	X										X	MMS (2007a); BOEMRE (2011); BOEM (2015a) ;BOEM (2017)
Oil Spill Planning and Response	Mitigation and reporting measures within regulations to minimize risk to marine mammals.	X	X	X		X	X				X	X											MMS (2007a); BOEMRE (2011); Shell (2011); BOEM (2012a); NMFS (2012k); BOEM (2016); BOEM (2018); NMFS (2019c) BOEM (2019)
Orientation Program/Crew Briefings	For all personnel involved in the action; must have sufficient detail to inform personnel of specific environmental, safety, social, and cultural concerns.	X	X	X		X	X				X	X				X	X	X	X	X	X	X	BOEMRE (2011); USACE (2012); BOEM (2015a); BOEM (2016); BOEM (2018); Hilcorp Alaska LLC and Harvest Pipeline (2019);
Power Down	Immediate reduction in noise/energy sources. Initiated when a marine mammal approaches the safety zone.[8]	X	X	X		X	X	X	X	X	X					X	X	X	X	X	X		NMFS (2009); NMFS (2010a) BOEMRE (2011); BOEM (2012a); NMFS (2012k); SAExploration (2012); BOEM (2014a); USFWS (2014e); BOEM (2015a); NMFS (2015b); NMFS (2015g); BOEM (2016); NMFS (2016c); NMFS (2016f); BLM (2019); Hilcorp Alaska LLC and Harvest Pipeline (2019); BLM (2020b)
Protected Species Observers (PSOs)	PSOs monitor safety and disturbance zones from land, fixed infrastructure (*i.e.*, platforms or docks), vessels or aircraft. PSOs monitor during pre-clearance surveys, exploration drilling, development and production, marine transit operations; and construction activities. Also adds species observation data to databases.	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	NMFS (2006a); BOEMRE (2011); LGL Ltd. and Marine Acoustics Inc. (2011); Shell (2011); BOEM (2012a); SAExploration (2012); NMFS (2012j); NMFS (2012k); USACE (2012); BOEM (2014a) USFWS (2014e); BOEM (2015a); NMFS (2015b); NMFS (2015g); BOEM (2016) NMFS (2016c); NMFS (2016f); BOEM (2018); Fairweather Science LLC (2018); NMFS (2018a); Sitkiewicz *et al.* (2018); BLM (2019); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2019c); BLM (2020b); NMFS (2020a) (NMFS 2005b)
Ramp Up and Soft Start	Allows marine mammals to leave the area prior to full sound or energy source initiation	X	X	X			X	X	X	X						X	X	X	X	X	X		Shell (2011); BOEM (2012a); NMFS (2012j); NMFS (2012k); SAExploration (2012); NMFS (2013a); BOEM (2014a); USFWS (2014e); BOEM (2015a) ;BOEM (2016); NMFS (2016c); NMFS (2016f); BOEM (2018); Fairweather Science LLC (2018); Sitkiewicz *et al.* (2018); NMFS (2019c); NMFS (2020a)
Shutdown	Immediate cessation of all energy/noise sources. Initiated when a marine mammal enters the safety or exclusion zone[10]	X	X	X		X	X	X	X	X	X		X			X	X	X	X	X	X		BOEM (2012a); NMFS (2012j); NMFS (2012k); SAExploration (2012); BOEM (2014a); BOEM (2015a) ; BOEM (2016); NMFS (2016c); NMFS (2016f); BOEM (2018); Fairweather Science LLC (2018); Sitkiewicz *et al.* (2018); NMFS (2020a)
Waste Streams	Trash management. Effluent management (*i.e.*, zero discharge); recycling of drilling muds	X	X	X			X	X			X	X											BOEMRE (2011); Shell (2011); NMFS (2012k); BOEM (2016); NMFS (2016f); Hilcorp Alaska LLC and Harvest Pipeline (2019)

Measure	Brief Description	Region: Cook Inlet	Region: Chukchi Sea	Region: Beaufort Sea	Season: Marine Transit Route	Season: Ice-covered Conditions	Season: Open Water	Activity: Seismic Surveys (OBC/OBN)	Activity: Site Clearance[1]	Activity: Non-impulsive Vibroseis	Activity: Exploratory Drilling Noise	Activity: Development Drilling and Production	Activity: Anchor Management	Activity: Vessel Transit	Activity: Aircraft	Activity: Pile-Driving/Drilling	Activity: Dredging/Screeding	Activity: Gravel Placement (Fill)	Activity: Pipeline Installation (Trenching)	Activity: Pipeline Maintenance/Replacement[2]	Activity: Pile/Pipe Removal	Activity: Decommissioning, Abandonment, and Reclamation[3]	Selected Citations
Vessel Management	Speed limits, altering direction, vessel behavior (*i.e.*, do not separate mother-calf pairs or separate "groups" of cetaceans. Pre-booming required for fuel transfers. SSV required for ice breakers.	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	(NMFS 2005b) LGL Ltd. and Marine Acoustics Inc. (2011); Shell (2011); BOEM (2012a); NMFS (2012k); BOEM (2014a); USFWS (2014e); BOEM (2015a); BOEM (2016) NMFS (2016c); NMFS (2016f); BOEM (2017); BOEM (2018); Fairweather Science LLC (2018); BLM (2019); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2019c); BLM (2020b)
Specific Vessel Transit Routes and Timing	Avoidance of Pacific Right Whale Critical Habitat and other regulations and safety requirements for exploratory drilling[11]	X	X	X	X		X	X						X									NMFS (2005b); NMFS (2006a); NMFS (2007e); BOEM (2012a) NMFS (2012j); NMFS (2012k) USACE (2012); NMFS (2016f); BOEM (2018); NMFS (2019c) BLM (2019); BLM (2020b)
Uncrewed Aircraft Systems (UAS)-Based Monitoring	To assist PSOs in monitoring very large safety or disturbance zones.	X		X			X	X								X	X	X	X	X			BOEM (2018); Fairweather Science LLC (2018); NMFS (2019c)
Measures Specific to Sea Ice Roads, Trails and Pads																							
Annual Decommissioning of Ice Roads and Pads	Cannot occur within 50 m of observed ring seals; may proceed after seal has moved of its own accord or has not been observed for 24 hours.			X		X																X	NMFS (2019c)
Surveys for Polar Bears and Seals	Along proposed ice road routes and existing ice roads; includes surveying for dens and lairs.			X		X																	USACE (2012); USFWS (2013); BOEM (2018); BLM (2019); BLM (2020b); NMFS (2019c); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2020c)
Conduct Wildlife Training	Project personnel (*i.e.*, ice road construction workers, surveyors, security personnel, and the environmental team) will receive annual training on implementing mitigation and monitoring measures.			X		X																	BOEM (2018); NMFS (2019c); Hilcorp Alaska LLC and Harvest Pipeline (2019); NMFS (2020c)
Delineate Road/Tail	Markers delineate roads/trails to keep traffic on the defined route.			X		X																	NMFS (2019c); NMFS (2020c)
Ice Road, Trail and Pad Measures to Protect Ringed Seals	Measures for sea ice routes and pads in depths greater than 3 m or areas with leads/cracks. Not applicable to ice roads on land or shallower depths.			X		X																	NMFS (2012a); NMFS (2012e); NMFS (2012g); NMFS (2012h); NMFS (2019c); NMFS (2020c); NMFS (2020d)
Ice Road Use and Speed Limit	Ice road/trail speed limits will be no greater than approximately 74.5 km (45 miles) per hour under typical circumstances but may be exceeded in emergency situations. Vehicles will not stop within 50 m (164 feet) of identified seals or within 150 m (500 feet) of known seal lairs.			X		X																	NMFS (2019c); NMFS (2020c)

Measure	Brief Description	Region			Season			Activity for Which Measure Is Implemented															Selected Citations
		Cook Inlet	Chukchi Sea	Beaufort Sea	Marine Transit Route	Ice-covered Conditions	Open Water	Seismic Surveys (OBC/OBN)	Site Clearance[1]	Non-impulsive Vibroseis	Exploratory Drilling Noise	Development Drilling and Production	Anchor Management	Vessel Transit	Aircraft	Pile-Driving/Drilling	Dredging/Screeding	Gravel Placement (Fill)	Pipeline Installation (Trenching)	Pipeline Maintenance/Replacement[2]	Pile/Pipe Removal	Decommissioning, Abandonment, and Reclamation[3]	
Monitoring Requirements for Ringed Seals	Monitor and report all seals within 50 m of the center of an ice road. After March 1 conduct surveys for seals and seal structures within 150 m of the road. Monitor if observed.			X		X																	NMFS (2019c); NMFS (2020c)
Seasonal Restrictions	Construct sea ice roads as early as possible so the corridor is disturbed prior to March 1.			X		X																	NMFS (2012j); BOEM (2018); BLM (2019); NMFS (2019c); BLM (2020b);NMFS (2020c)
Snow Blowing/ Clearing	Blading and snow blowing of ice roads/trails limited to previously disturbed and delineated areas.			X		X																	NMFS (2019c); NMFS (2020c)
Protection of Marine Mammals in the Vicinity of Ice Roads	General measures apply to polar bears, polar bear dens, ringed seals and ringed seal lairs polar bears and polar bear dens.		X	X																			USACE (2012); BOEM (2018); BLM (2019); NMFS (2019c); Hilcorp Alaska LLC and Harvest Pipeline (2019); BLM (2020b); NMFS (2020c).

[1] Using echosounder, sub-bottom profiler, side-scan sonar, or magnetometer.
[2] Using Caviblaster™ or underwater saws/drills.
[3] Subject to regulations at the time of decommissioning; activities indicated are assumed based on current regulations.
[4] Also includes acoustic monitoring using dipped hydrophones from vessels or in-water infrastructure (*i.e.*, platform or dock).
[5] PAM has been used in Cook Inlet but is generally not required.
[6] Geospatial avoidance by designing the project to avoid subsistence areas, sensitive habitat, or other specific areas. Project scheduling: timing/sequencing of activities or seasonal restrictions. For example, construction during winter to avoid open water, avoiding activities during high fish runs or migration periods, or pile-driving only for certain periods of each day.
[7] Must include a: 1) statement that the applicant has notified and provided the affected subsistence community with a draft POC; 2) schedule for meeting to discuss planned activities and to resolve potential conflicts; 3) description of measures taken to ensure activities will not interfere with whaling or sealing; and 4) plans for future meetings with subsistence communities regarding any changes in plans, etc.
[8] This measure helps ensure early planning by industry to prevent or reduce potential conflicts with subsistence, sport, and commercial fishing, and is useful in preventing interference with fishing interests by seismic surveys that could cause damage or loss of fixed fishing gear.
[9] Includes use of mitigation airguns.
[10] Operations do not resume until the animal has cleared the zone or has not been observed for 30 minutes.
[11] Avoidance of Pacific Right Whale Critical Habitat and Regulations and safety requirements for exploratory drilling put into place for Alaska OCS based on Deepwater Horizon (July 15, 2016; 81 FR 46477) - drilling dates restricted by "trigger date" for potential ice conditions. All oil and gas industry exploration vessels shall complete operations in time to allow such vessels to complete transit through the Bering Strait to a point south of 59 deg. No later than November 15.

6.1. Acoustic Monitoring

Acoustic monitoring to support mitigation efforts has several goals: 1) characterize ambient conditions; 2) determine if marine mammals are (or could be in the future) using potentially impacted habitats; 3) support vessel based monitoring during noise producing activities; and 4) obtain acoustic data during noise producing activities (*i.e.*, sound source verification or SSV) to establish safety zones and disturbance radii (Fairweather Science LLC 2018). Passive acoustic monitoring (PAM) techniques described in Section 6.1.1 are used to meet these goals. Data obtained for SSV is used to conduct acoustic modeling and establish safety zones and disturbance radii (Section 6.1.2).

6.1.1. Passive Acoustic Monitoring

PAM is conducted by deploying Autonomous Multichannel Acoustic Recorders (AMARs) or Directional Autonomous Seafloor Acoustic Recorders (DASARs) (NMFS 2012j). In some instances, PAM is conducted using over the side hydrophones placed in the water column from vessels or in-water infrastructure (*i.e.*, platform or dock).

AMARs are electronic recording devices that acquire and store scientific data while moored semi-permanently underwater (Figure 6-1). The device archives the acoustic data and must be retrieved for posting and data analysis (Sousa-Lima *et al.* 2013). The use of AMARs is an effective method for acoustically monitoring marine mammals including identifying which species are present or absent, and determining relative abundance (Sousa-Lima *et al.* 2013). AMARs can also include oceanographic sensors to record environmental parameters such as oxygen, salinity, temperature, and turbidity.[21] DASARs are instruments that couple an acoustic recorder with omnidirectional or two orthogonal horizontal sensors, as well as a magnetic compass, which are deployed from a sonobuoy (Norman and Greene 2000). This provides a directional component to the acoustic data.

Figure 6-1. AMAR

Source: https://www.jasco.com/amar

[21] https://www.jasco.com/amar; (Accessed August 2, 2021)

Data gathered using PAM are used to inform users of potential after-the-fact impacts, as well as ambient and biological sound levels and sound sources. This information typically supports future ESA and MMPA consultations for similar work, and supplements visual monitoring from vessels, aircraft or Uncrewed Aircraft Systems (UAS) (Fairweather Science LLC 2018). For example, underwater and in-air production sounds from Northstar Island were recorded and characterized during open-water seasons from 2001 to 2016 (Blackwell and Greene Jr. 2006; Blackwell *et al.* 2009; Greeneridge Sciences Inc. 2017). These data have been used in subsequent authorizations for work in the Beaufort Sea (NMFS 2006a, 2007d, 2008c, 2014f, 2020e). During seismic surveys, acoustic monitoring can be used in addition to visual monitoring to detect marine mammals approaching or within the exclusion zone and trigger the shutdown of airguns (Abadi *et al.* 2017). Acoustic monitoring is applicable when conducting 2D/3D seismic surveys, including in-ice surveys and site clearance and high-resolution shallow hazards surveys (BOEMRE 2011; LGL Ltd. and Marine Acoustics Inc. 2011; SAExploration 2012; NMFS 2016f, c).

Together with PSOs, PAM is an effective tool that may detect marine mammals prior to and during underwater activities that may produce noises that exceed regulatory thresholds. In times of low visibility (*e.g.*, darkness or inclement weather), PAM in combination with PSO surveys of the exclusion zone(s), may increase the ability to minimize exposure of marine mammals to higher levels of sound that may cause injury or more severe behavioral responses (NMFS 2016f). By using PAM devices, operators can ramp-up and start/resume a seismic survey during times of reduced visibility when such ramp-up otherwise would not be permitted.

PAM has also been used to detect bowhead whale calls during migration and characterize other marine mammals that may be present (Norman and Greene 2000; Greene *et al.* 2004; NMFS 2012k). In addition to collecting sounds associated with construction, drilling, and production at Northstar Island as described above, data on underwater sounds were obtained during the fall whale migration (late August to early October) via: 1) boat-based recordings 0.3-37 km from the island (2000-2003); 2) a cable hydrophone (2000-2003) and DASARs (2003-2016) deployed approximately 450 m north of Northstar; and 3) DASARs deployed within a range of 6.5-38.5 km north of Northstar (NMFS 2012j; Greeneridge Sciences Inc. 2017). The Northstar acoustic monitoring program is ongoing (Richardson and Williams 2001; Richardson and Williams 2002; Richardson and Williams 2003, 2004; Miller *et al.* 2005; Richardson and Williams 2005; Richardson 2006; Richardson 2007; Aerts and Richardson 2008; Richardson 2008; Aerts and Richardson 2009, 2010; Richardson 2011; Kim and Richardson 2016; Kim and Richardson 2020a, b). Results are typically published annually, though some annual reports may be delayed for various reasons. These data have also been used to support MMPA and ESA mitigation requirements. For additional discussion on the results of the long-term Northstar acoustic monitoring program, see Section 7.1.4.2.

In the final rule for incidental taking of marine mammals during oil and gas activities in Cook Inlet (NMFS 2019a), NMFS noted that PAM has been required in previous incidental take authorizations in Cook Inlet. However, the 2019 authorization stated that the PAM efforts did not provide data useful to inform mitigation and monitoring during project activities and that advances in technology are needed to make PAM a practical mitigation measure. In addition, in a study using PAM to monitor cetaceans in Cook Inlet during a 3D seismic survey, (Castellote *et al.* 2020) states that a more robust framework for considering disturbance effects is needed to assess and mitigate acoustic impacts related to spatial displacement or auditory masking.

6.1.2. Acoustic Modeling and Sound Source Verification

Acoustic modeling must take into consideration factors that affect sound propagation in the marine environment including: bottom topography and substrates; water temperature and salinity; water depth and source depth; wind and waves; absorption; and area-specific ambient noise (LGL Ltd. and Marine Acoustics Inc. 2011). Modeling algorithms are used to calculate the transmission loss between the sound source and the receiver. For example, the modeling algorithm *RAMGeo* was used to model the extent of noise propagation from construction and operation at the proposed Liberty Development in Foggy island Bay (NMFS 2019c). Modeled distances to injury and disturbance thresholds are used to characterize the ensonified area and subsequently to identify safety zones and disturbance radii and to assess potential impacts to marine mammals.

SSV is the measurement of sound SLs and associated propagation properties to verify distances at which rms SPLs reached disturbance threshold levels (NMFS 2012j; LGL Alaska Research Associates Inc. *et al.* 2014). The threshold sound radii are used as criteria for the implementation of mitigation measures for marine mammals such as power downs and shutdowns BOEMRE (2011); (LGL Ltd. and Marine Acoustics Inc. 2011; BOEM 2012a; NMFS 2012k; BOEM 2014a; NMFS 2016f, c; BLM 2019, 2020b). For acoustic modeling associated with the Liberty Development, Hilcorp relied on operational data from Northstar to estimate sound SLs and duration associated with construction activities (NMFS 2019c).

Modeled sound level radii are verified through field measurement using PAM (BOEMRE 2011). As described in Section 6.1.1, this monitoring measures the sound levels produced by exploration, vessels, construction, or drilling and development activities including variations with time, distance, and direction from the noise producing activity. Methods include deploying AMARS or DASARS, or in the case of vessels, employing hydrophones placed into the water column.

In a recent example of using acoustic monitoring for SSV, during construction of a pipeline in Cook Inlet a PAM package was deployed 1 km north of the pipeline corridor for 128 days during construction. A total of six noise sources were identified and linked to the construction activities, plus an unknown source of mechanical machinery. Results demonstrate that, during pipe pulling from a winch barge, winch noise and pipeline drag generate tonal and impulsive signals, but broadband vessel noise was the primary source of acoustic disturbance (Castellote 2019). The data collected during this study provide information for understanding the effects of anthropogenic noise on endangered Cook Inlet beluga whales and provide insight on how to manage the effects of anthropogenic noise to promote species recovery (Castellote *et al.* 2019).

6.2. Aircraft Management

The use of aircraft for surveys and monitoring during oil and gas activities is managed to avoid disturbance to wildlife including marine mammals. Altitudes, aircraft behavior, and flight routes are designated and enforced to protect wildlife, except for during takeoff, landing, or in emergency situations.

6.2.1. Altitudes

For decades, lease sale stipulations and IHAs have designated a minimum altitude for aircraft activity, except when taking off or landing, or in certain conditions such as poor visibility or an emergency (MMS 2003a, b, 2008; NMFS 2015i; USFWS 2015a; NMFS 2016f). Aircraft flight paths and altitudes are restricted to reduce the chance of disturbing marine mammals in the water or hauled out on the ice or land. Additionally, this mitigation measure is intended to ensure no unmitigable adverse impacts occur to subsistence hunters from the anticipated increases in levels of aircraft overflights during oil and gas exploration activities (NMFS 2016f). Most offshore aircraft traffic that supports oil industry activities involves turbine helicopters flying along straight lines. Underwater sounds from aircraft are transient. The angle at which a line from the aircraft to the receiver intersects the water's surface is important. When the angle is greater than 13 degrees (°) from the vertical, much of the sound is reflected from the water surface and does not penetrate the water column. Strong underwater sounds are detectable while the aircraft is within a 26° cone above the receiver (Richardson *et al.* 1995). An aircraft usually can be heard in the air well before and after the brief period while it passes overhead and is heard underwater (MMS 2003a).

As summarized in MMS (2003a), data on reactions of bowheads to helicopters are limited. Most whales are unlikely to react in a meaningful way to occasional single passes by low-flying aircraft. Observations of bowhead whales exposed to helicopter overflights indicate that most bowheads exhibited no obvious response to helicopter overflights at altitudes above 150 m. Fixed-wing aircraft flying at low altitude often cause whales at the surface to dive immediately. Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m, uncommon at 460 m, and generally undetectable at 600 m (MMS 2003a). Fixed-wing aircraft and helicopter flights over ice can disturb seals hauled out on the ice, but the flight altitude and lateral distance required to cause a reaction from animals are variable (Burns and Harbo 1972; Frost and Burns 1989). Evidence from fly over studies of ringed and bearded seals indicates that reactions to helicopter occur more commonly than to fixed-wing aircraft (NMFS 2015g).

For example, to protect marine mammals from fixed-wing aircraft disturbance, mitigation measures in NMFS (2012j) stipulate that fixed-wing aircraft would not operate below 457 m, unless engaged in marine mammal monitoring or approaching landing or takeoff; providing assistance to whalers; in times of low ceilings; or in any emergency situation. All aircraft engaged in active whale monitoring would not operate below 457 m in areas of active whaling. Except when limited by weather or personnel safety, helicopters shall maintain a minimum altitude of 305 m, except during takeoff and landing. Recent BiOps and IHAs maintain these mitigation measures for fixed-wing aircraft (NMFS 2017b, 2018b, 2019a, 2020e). For Shell's work associated with aerial monitoring of ice conditions May 2015 to April 2016, NMFS' BiOp stated that that except when encountering marine mammals, altitudes for all fixed-wing flights were to be at or above 152 m. Helicopter altitudes were at or above 61 m (NMFS 2015g). The IHA for this activity required that aircraft maintain an altitude of 305 m until offshore area of interest were reached (NMFS 2015a).

6.2.2. Aircraft Behavior Over Haulouts or Marine Mammals in Water

Mitigation measures associated with aircraft altitude and behavior over terrestrial haulouts or marine mammals on ice or in the water have been defined in lease sale EISs, EAs, IHAs, and BiOps (MMS 2006; NMFS 2006a; USFWS 2006; BP Exploration Alaska 2009; NMFS 2012j, 2014d; USFWS 2014a; BOEM 2015c; NMFS 2015g, a; USFWS 2016c; BLM 2019, 2020a). Aircraft noise may flush pinnipeds from haulouts. Reactions of seals to aircraft over their haulouts range from simply becoming alert and raising the head, to escape behavior such as rushing to the water (Shell 2011). Ringed seals hauled out on the surface of the ice have shown behavior responses to helicopter overflights with escape response most probable at lateral distance of <200 m and overhead distances <150 m (Born *et al*. 1999, as cited in Shell 2011). Walrus reacted to flights between 60 and 150 m above sea level within 1 km lateral distance by either orienting towards the aircraft or escaping into the water (Brueggeman *et al.* 1990, as cited in Shell 2011). In recent years, when ice has retreated offshore beyond the continental shelf break, walrus have moved to terrestrial haulout sites along the Chukchi Sea coast (Shell 2011). Stampedes at these large haulouts can result in deaths of animals, particularly smaller juveniles and calves, as happened in 2009. Denning polar bears may abandon or depart their dens early in response to repeated noise (USFWS 2015a). When disturbed by aircraft noise, sea otters may respond behaviorally (escape) or physiologically (increased heart rate and hormonal changes) (Harms *et al*. 1997, as cited in USFWS 2014a).

Examples of specific mitigation measures to address impacts to hauled out animals and animals in water have included: aircraft will not operate within 0.8 km of walrus or polar bears on ice (Shell 2011), and aircraft may not land within 1.6 km of hauled out pinnipeds (NMFS 2015a). Altitude designations described in Section 6.2.1 should reduce the disturbance to polar bear, ringed seals, bearded seals, and walrus hauled out or in the water. Regarding sea otters in Cook Inlet, fixed-wing aircraft must operate at altitudes no lower than 91 m in the vicinity of sea otters, and rotary-wing aircraft must operate no lower than 305 m; further, if due to safety concerns altitudes lower than these are necessary, the operator must avoid flying directly over otters (USFWS 2014d, a).

6.2.3. Aircraft Flight Routes

Mitigation measures have stipulated that specific flight corridors be used to minimize impacts to marine mammals in the water or hauled out on the ice or land (NMFS 2006a, 2012j, d, k; BOEM 2014a, b; USFWS 2014a; NMFS 2015a; BLM 2019, 2020a). Additionally, this mitigation measure is intended to ensure no unmitigable adverse impacts occur to subsistence hunting activities from the anticipated increases in levels of aircraft overflights during oil and gas exploration activities. For example, aircraft routes in the vicinity of Cross Island during the fall bowhead whale hunt have been limited (BP Exploration Alaska 2009), and helicopter flights to support Northstar activities have been flown in a designated path from Seal Island to the mainland (NMFS 2012j). In Lower Cook Inlet, aircraft routes must be planned to minimize any potential conflicts with anticipated sea otter gatherings and with subsistence hunting, as determined though community consultation (USFWS 2014d). As with designated aircraft altitudes, designated flight corridors are not applicable in times of poor visibility, poor weather conditions, or in an emergency.

6.3. Avoidance

The timing and location of oil and gas activities, including support activities, can be important mitigation measures. Activities can be located or relocated or seasonally scheduled to avoid causing direct impacts on marine mammals or to avoid causing impacts on subsistence hunting endeavors. Often these measures have both a geospatial and temporal component.

6.3.1. Geospatial Avoidance

Designation of flight paths, flight corridors, and aircraft altitude restrictions described in Section 6.2 are all good examples of geospatial avoidance to protect marine mammals. In addition, vessel routes can be designated to avoid things like right whale critical habitat, bowhead whale migration corridors, and subsistence hunts. These measures associated with vessel management are discussed in Section 6.13. CAAs and POCs (see Section 6.5) provide avoidance guidelines and other mitigation measures to be followed by the industry.

Specifically, mitigation measures over the years have addressed the spatial avoidance of seals and seal structures (i.e., lairs and breathing holes) during on ice work such as ice road construction and maintenance or on-ice seismic studies (ADNR 2001b; NMFS 2001; ADNR 2003a; NMFS 2003a, 2004, 2005a, 2006a, b, 2007a, c; ADNR 2008; NMFS 2008a, g; BP Exploration Alaska 2009; NMFS 2012j; BOEM 2014b; NMFS 2015e; 2016f ; ADNR 2019). This has culminated in NMFS issuing specific regulations under the MMPA for the taking of small numbers of marine mammals incidental to ice road and ice trail construction maintenance and operation in Alaska's North Slope over the period 2020-2025 (NMFS 2020c). For example, as stated in the 2020 final rule for ice road, trail, and pad activities on Alaska's North Slope, there can be no initiation of an ice road or trail construction if a ringed seal is observed within approximately 46 m of the action area after March 1 through May 30 of each year (NMFS 2020c). The final rule designating critical habitat for Cook Inlet beluga whales identified specific areas as critical habitat in Upper Cook Inlet (including Knik and Turnagain arms), Kachemak Bay, and the nearshore waters along the west coast of Lower Cook Inlet. The rule specifically designated "Area 1" in northern Cook Inlet that encompasses the Susitna River delta and includes important beluga feeding areas (NMFS 2011a). Project-specific mitigation measures to protect Cook Inlet beluga whales have included not allowing seismic surveys within 16 km of beluga feeding areas near the Susitna River delta (NMFS 2012l, 2013e, a, 2019f).

6.3.2. Temporal Avoidance

Temporal avoidance as a mitigation measure can been accomplished using project scheduling. For example, construction projects in the U.S. Arctic are often scheduled during ice-covered season to avoid encountering, and potentially impacting, marine mammals. An example of this specific mitigation measure is the construction and pipeline trenching for Northstar, which was accomplished during the winter months when whales would not be present; the same is planned for the Liberty Development with the majority of sheet pile driving activities also planned during the ice covered season (USACE 1999; BOEM 2018).

Temporal avoidance can also be focused on potential oil spill response. In a 2012 BiOp, mitigation measures included requiring Shell to leave sufficient time to implement cap and containment operations as well as clean up before the onset of sea ice in the event of a loss of well control. Shell was required to cease drilling 38 days before the anticipated first date of ice encroachment over the drill site, anticipated as November 1 (as based on a 5-year analysis of historic weather patterns). The 38-day period also provided a window for drilling a relief well, if needed (NMFS 2012i). The mitigation measure of avoiding drilling, or not drilling into oil bearing strata, during periods of open-water or broken ice conditions is seen in many project plans, lease stipulations, impact assessments, and permits (USACE 1999; ADNR 2001a, 2002a; MMS 2002a; NMFS 2002, 2012j, 2014d; BOEM 2018; ADNR 2019).

Since the mid-1980s, seismic surveys and exploratory drilling activities in the Chukchi and Beaufort seas are timed to avoid conflicts with the bowhead whale hunt, with operations generally suspended or curtailed after August 25th (USACE 1999; NMFS 2002, 2007a, 2008e; BOEMRE 2011; NMFS 2012h, c, f, 2013d; BOEM 2014a; NMFS 2014b, e, 2016e; FERC 2019). This collaboration between the subsistence hunters and offshore oil and gas operators is centered on an agreement, which is revised on an annual basis. Such revisions are often made during face-to-face meetings known as the “CAA Process”. Discussions between bowhead whale subsistence hunters (through their representative organization), the AEWC, and offshore oil and gas operators address the challenge of managing offshore industrial development (Levfevre 2013). For additional detail on the CAA process, see Section 6.5.

For example, in 2012 to avoid the bowhead whale hunting season ION was to conduct a unique in-ice geophysical survey (seismic reflection/refraction) from a seismic vessel escorted by a medium class icebreaker moving from east to west through the Beaufort Sea, following the bowhead whale migration, through ice if necessary. Historically, on average more than 95% of bowheads have passed through the eastern U.S. Beaufort Sea by October 15th. In-ice surveys were to start in the eastern Beaufort Sea in late October or early November 2012, avoiding bowhead whales (NMFS 2012f). Also, to minimize impacts to marine mammals, drilling vessels and support fleet would not transit north through the Bering Strait until July 1st and exit no later than November 15th (BOEMRE 2011; NMFS 2012k, 2015b, 2016b, 2017a; USFWS 2017b).

During ice road construction and maintenance, impacts to ice seals can be avoided by ensuring that activities in undisturbed areas are initiated by March 1st (NMFS 2020c). Prior to March 1st, seals are denning and will avoid setting up their lairs in areas with active disturbance. After March 1st, measures are in place to protect seals and seal lairs through spatial avoidance (see Section 6.3.1).

Marine seismic activity is not allowed in Cook Inlet within 16 km of the MHHW line of the Susitna Delta (the area from Beluga River to Little Susitna River) from mid-April to mid-October so as to avoid any effects to beluga whales and their prey in this critical feeding and potential breeding area (NMFS 2012b).

6.4. Conduct Biological Studies

If populations or habitats that may require additional protection are identified, biological surveys may be required to determine the extent and composition of populations and habitats that could be impacted. For example, the Northstar EIS included a requirement that BP Exploration (Alaska), Inc. (BPXA) design studies to report the impact of its activities on the migratory path of bowhead whales (USACE 1999). MMS lease stipulations (MMS 2002b, 2003a, 2007b), and later BOEMRE and BOEM stipulations (BOEMRE 2011; BOEM 2015a, 2017), included a requirement that industry conduct site-specific bowhead whale monitoring programs to determine when bowhead whales are present in the vicinity of lease operations during exploratory drilling activities and seismic surveys, and to assess the extent of behavioral effects on bowhead whales due to these activities. BOEM (2015a) states that lessees may have to conduct site-specific monitoring programs for marine mammal subsistence resources in areas identified as being important to marine mammal subsistence hunting.

6.5. Conflict Avoidance Agreements and Plans of Cooperation

CAAs are developed between Alaska Native subsistence communities and industry to minimize the potential impacts of oil and gas on subsistence activities. The NSB typically requests offshore oil and gas operators to enter into a CAA with the AEWC (ADNR 2019). AEWC first started development of an Open Water Season CAA in 1985 for the 1986 operating season (Levfevre 2013). The goal of the CAA is to balance development with subsistence needs so that resources and livelihood are protected while the economic benefits of development are realized. The CAA process for offshore development planning in the U.S. Arctic has been codified and allows AEWC and the NSB to be a part of the scientific review process for offshore development (Levfevre 2013).

CAAs are formal agreements between the oil and gas industry and coastal communities and provide:

a. Equipment and procedures for communications between Subsistence Participants and Industry Participants;

b. Avoidance guidelines and other mitigation measures to be followed by the Industry Participants working in or transiting the vicinity of active subsistence hunters, in areas where subsistence hunters anticipate hunting, or in areas that are in sufficient proximity to areas expected to be used for subsistence hunting that the planned activities could potentially adversely affect the subsistence bowhead whale hunt through effects on bowhead whales;

c. Measures to be taken in the event of an emergency; and

d. Dispute resolution procedures.

There is a documented history regarding the utilization of CAAs to formally address and mitigate the potential interference of subsistence hunting for bowhead whales in the Beaufort and Chukchi seas. AEWC (2011) provides a good example of what is included in such an agreement. This is the CAA for 2011 open-water work between industry and the AEWC including the six village whaling captain associations. It covered Beaufort and Chukchi sea waters and terminated on completion of the fall bowhead whale hunts. Mitigation measures in the agreement were intended to minimize interference by oil and gas and barge and transit operations with the subsistence bowhead whale hunt of 2011. Included were provisions for emergency communications and emergency assistance for subsistence whale hunters. Pre- and post-season village meetings were required. Mitigation measures stipulations included:

1. Using PSOs on primary offshore vessels; reporting of positions by whaling captains;
2. Avoiding hunting crews and areas;
3. Staffing of call centers by Inupiat operators;
4. Providing and return of communication equipment;
5. Providing industry contact lists;
6. Requirements for SSV testing;
7. Requirements for individual monitoring plans; and

8. Reporting requirements.

The CAA also called for anthropogenic noise mitigation and a cumulative noise impacts study. Specific mitigation measures included:

1. Planning of vessel and aircraft routes;

2. Allowing no aircraft below 457 m;

3. Restricting vessel speeds to less than 10 kts near feeding whales and 5 kts within 274 m of bowhead whales;

4. Steering around whales; and

5. Checking around waters to ensure that no whales would be injured when the propellers are engaged.

Lastly the CAA limited geophysical activity in the Beaufort and Chukchi seas.

Mitigation strategies in CAAs (AEWC 2011) that provide the relief necessary for hunters to successfully take bowhead whales have been included in numerous BiOps and IHAs:

- Suspending of operations in late August until completion of hunting efforts out of Nuiqsut and Kaktovik (NMFS 2012e);
- Initiating surveys in offshore areas prior to the arrival of migrating bowhead whales (NMFS 2013c);
- Establishing communication protocols allowing industry to inform hunters regarding their activities and vice versa (NMFS 2013d);
- Requiring PSOs on some seismic vessels and the limiting of operations during low visibility periods (NMFS 2015h);
- Establishing 800 - 1000 m safety/shutdown zones for dredging and screeding (NMFS 2018e, 2019g);
- Establishing seasonal construction limitations (NMFS 2000); and
- Establishing 180 dB shutdown zone (NMFS 2006a).

Based on CAAs between subsistence hunters and industry, and the agreement by industry to mitigate potential impacts on subsistence hunters, NMFS has determined (in numerous Federal Register notices) that oil and gas activities, as proposed, would not have an unmitigable adverse impact on the availability of bowhead whales to Alaska Native subsistence hunters (NMFS 2002, 2003b, 2006c, 2008f, b, 2009, 2011b, 2012c, 2019c).

An alternate approach to mitigating potential for oil and gas activities to interfere with Alaska Native subsistence hunting is for the industry to develop a POC. Regulations at 50 CFR § 216.104(a)(12) require IHA applicants for activities that take place in U.S. Arctic waters to provide a POC or information that identifies what measures have been taken or will be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. This approach requires NMFS to determine if the POC is adequate for mitigating potential interference between the proposed activity and Alaska Native subsistence hunting. This approach does not require a formal agreement by the industry with the communities potentially impacted by the activity. Examples of POCs include Shell Gulf of Mexico Inc. (2011b), Shell Offshore Inc. (2011), and Hilcorp Alaska LLC (2015).

6.6. Engineering Measures

6.6.1. Directional Drilling

Engineering measures can be considered as mitigation for adverse effects. For example, the Pt. Thomson Development Project used long-reach directional drilling to produce reservoir resources lying mainly offshore. Directional drilling is the process of drilling a well, "down a path that begins vertical to the surface similar to conventional drilling, but then changes the direction of the drill to an angle more horizontal to the surface" (USACE 2012). A more direct approach would have been to access the offshore resources from gravel islands or platforms; however, the chosen approach minimized potential impacts in marine waters (USACE 2012). To ensure that all casing and cementing of wells is done correctly, these programs have been required to be certified by a registered professional engineer (Shell 2011).

6.6.2. Double-Hulled Vessels

In 1992, the International Convention for the Prevention of Pollution from Ships (MARPOL) was amended to make it mandatory for tankers > 5,000 deadweight tons and more ordered after July 6, 1996 to be fitted with double hulls, or an alternative design approved by the International Maritime Organization (IMO) (IMO 1992). Double-hulled tankers can be important in preventing spills due to tanker accidents and groundings. Crude oil is delivered by double-hulled tankers throughout Cook Inlet (BOEM 2016). Pursuant to the Oil Pollution Act of 1990, double-hulls are required on all newly constructed tankers and all barges less than 5,000 gross tons; single-hull tankers in the U.S. began to be phased out in 1995. As of January 1, 2015, the U.S. has phased out all single-hull tank vessels and all single-hull tank vessels with double sides or double bottoms that carry bulk oil in U.S. territorial waters and the U.S. Exclusive Economic Zone (BOEM 2019).

6.6.3. Blowout Restrictors

State lease sale stipulations have historically required oil spill contingency planning (ADNR 2001a, b, 2002a, b, 2003a, b, 2004, 2007, 2008). However, after the Deepwater Horizon incident, exploration and development plans and lease sale EISs and stipulations placed additional focus on blowout prevention programs (USACE 2012; BOEM 2015c; ADNR 2018; BOEM 2018; ADNR 2019). For example, the 2011 Shell Exploration Drilling Plan states that:

> *The blowout prevention program will be enhanced through the use of two sets of blind/shear rams, increased frequency of BOP performance tests from 14 days to 7 days, a remotely operated vehicle (ROV) control panel on the seafloor with sufficient pressured water-based fluid to operate the BOP, a containment system that includes both capping stack equipment and treatment and flaring capabilities, a fully-designed relief well drilling plan and provisions for a second relief well drilling vessel (e.g., Kulluk) to be available to drill the relief well if the primary drilling vessel is disabled and not capable of drilling its own relief well. (Shell Gulf of Mexico Inc. 2011a)*

In addition, subsea BOPs were required in projects post 2010 (BOEM 2015a, 2016, 2018).

6.6.4. Other Spill Response or Prevention

In 2019, BOEM published the Oil Spill Preparedness, Prevention, and Response on the Alaska OCS (BOEM 2019). The document is meant to provide readers with an understanding of oil spill preparedness, prevention, and response on the Alaska OCS. The report summarizes federal authorities and describes the National Response System, National and Local Contingency Plans, the Regional Response Teams, and BOEM and BSEE authority. The 2019 report also describes industry oil spill response planning and research, including descriptions of oil spill response organizations such as Alaska Clean Seas and Cook

Inlet Spill Prevention and Response, Inc. Offshore and nearshore countermeasures include mechanical countermeasures such as source control and containment and mechanical recovery, and non-mechanical countermeasures such as dispersants, surface collecting agents, and *in-situ* burning. The report describes supporting activities such as surveillance and monitoring, waste management, and response for wildlife threatened or impacted by spilled oil. If oil should reach the shore, the report describes how the Shoreline Cleanup Assessment Technique would be used to assess impacted shorelines and recommend barriers, flushing bioremediation, debris removal, or natural recovery. The BOEM report (2019) concludes:

> *Implementing the proper oil spill response planning, prevention, and response, in an effort to protect the environment and public health and safety, is essential for an efficient oil spill response that mitigates oil pollution damage.*

6.7. Exclusion Zones and Safety Zones

Acoustic modeling, as described in Section 6.1.2, is used to define ensonified areas and then safety and exclusion zones based on peak SELs that could cause harm or disturbance to marine mammals within the zone (NMFS 2016f). Mitigation measures typically used in industry programs include powering or shutting down activities (see Sections 6.8 and 6.11) if a marine mammal is in or approaching an established exclusion zone. These associated mitigation measures are intended to either give marine mammals a chance to swim away from potentially harmful sound sources or to minimize their risk of accidental exposure to such sounds (NMFS 2016f). The safety zone is an area established just outside of the exclusion zone, where animals are observed and monitored, and their behavior is documented. The safety radius provides a basis for reducing the SEL before a TS might occur.

Thresholds for disturbance or injury are based on recommended criteria (Southall *et al.* 2007; NMFS 2016g, 2018f; Southall *et al.* 2019b), and may be different for individual projects and the situations under which animals may be exposed. Under current NMFS guidelines, the ‘‘exclusion zone’’ for marine mammal exposure to impulse sources is defined as the area within which received sound levels are ≥180 dB (rms) re 1 mPa for cetaceans and ≥190 dB (rms) re 1 mPa for pinnipeds (NMFS 2016g). These safety criteria assume that sounds received at levels lower than these will not injure these animals or impair their hearing abilities, but that at higher levels might have some effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the exclusion zones (Richardson *et al.* 1995). Currently, NMFS uses 160 dB rms re 1 mPa as the threshold for Level B behavioral harassment from impulses noise (NMFS 2016g).

For example, in mitigation measures proposed in (NMFS 2016f), the disturbance exclusion zone corresponds to the area around the source within which received levels equal to or exceeding 160 dB re 1 mPa rms. Zones can be enhanced to minimize impacts in specific situations (for example, but not limited to, expansion of shutdown zones to 120 dB or 160 dB when cow-calf groups and feeding or resting aggregations are detected, respectively).

Rules associated with seismic surveys and early work at Northstar use the 180 dB exclusion zones for cetaceans and 190 dB for pinnipeds to prevent injury, and 160 or 120 dB to prevent disturbance (NMFS 2006a, 2007d, b, 2012b; BOEM 2013, 2015b; NMFS 2015i). Later rules incorporated recommended hearing group sensitivities (Southall *et al.* 2007; NMFS 2018f; Southall *et al.* 2019a, b) to designate specific injury exclusion zones for cetaceans and pinnipeds based on these hearing functions (NMFS 2014f, 2020e). *In lieu* of direct evidence regarding sound source characteristics that would cause TTS in Pacific walrus, the USFWS adopted the 180-dB safety radius for walruses as a precautionary measure.

6.8. Power Down and Shutdown Measures

Power down or shutdown measures are initiated when certain numbers or groups of marine mammals are seen entering or approaching the disturbance or exclusion zone (NMFS 2009, 2010b, 2012d, c, 2014e, 2015c). The purpose of these measures is to avoid marine mammal injury through PTS and to reduce the likelihood of TTS or more intense behavioral responses that might occur as a result of exposures to higher noise levels. By enacting these measures, injury or disturbance to marine mammals can be avoided. For seismic surveys, a power-down is the immediate reduction in the number of operating energy sources. A shutdown is the immediate cessation of firing of all energy sources. Mitigation measures specify that arrays be immediately powered down whenever a marine mammal is sighted approaching near or close to the applicable safety zone of the full arrays but is outside the applicable safety zone of the single source (NMFS 2009). If a marine mammal is sighted within the applicable safety zone of the single energy source, the entire array is shutdown (*i.e.*, no sources firing). Similar measures are required for pile and sheet pile driving, dredging, and screeding, and anchor handling and retrieval activities (NMFS 2013b, 2016a, f; BOEM 2018; NMFS 2018e, 2019g, 2020e).

After a power down or shutdown occurs, and before work initiates each day, a PSO would scan the waters 30 minutes prior to work starting, and not starting work if animals were observed to be present in the zone (see Section 6.9 for details on PSOs and starting or restarting work).

6.9. Protected Species Observers (PSOs)

The primary task of a PSO is to observe and record the presence of marine mammals and to call for shutdowns or power downs, as described in Section 6.8. As such, PSOs must be trained in species identification and data recording procedures. PSOs also collect required monitoring information such as the number of animals observed by species, what activities were occurring at the time animals were observed, behavior of the animal(s), and environmental conditions such as weather, sea state, and visibility.

To ensure PSO remain alert, they typically observe for no more than 4 hours at a time and not more than 12 hours in a 24-hour period. They watch for marine mammals from the best available vantage point, which is either the bridge or flying bridge on a vessel (NMFS 2009) or from an elevated point on land (NMFS 2020e). PSOs systematical scan the waters using appropriate ocular equipment to detect marine mammals within the safety and disturbance zones. This equipment can include 7 x 50 reticle binoculars, supplemented with 20 x 50 image stabilized binoculars, and night-vision equipment, if needed. PSOs give particular attention to the areas within designated safety or exclusion zones. PSO monitoring of the safety and exclusion zones is dependent on visibility and sea state. Work must be limited or shutdown if the PSO is unable to view the entire safety zone (BOEM 2012a; NMFS 2016f, c). Detecting marine mammals during periods of low visibility can be challenging and as such, MMPA authorizations may include requirements for shutting down or not starting noise-producing activities if visibility is so poor that marine mammals entering the established safety or exclusions zones could go undetected.

6.9.1. Pre-clearance Surveys

PSOs must monitor disturbance and shutdown zones for 30 minutes prior to the initiation of work each day (NMFS 2006a; Haley *et al.* 2010; BOEM 2013; NMFS 2013b, 2016a; Sitkiewicz *et al.* 2018; NMFS 2019g, c). Work may commence when observers have declared the shutdown zone clear of marine mammals. In the event of a delay in starting activity due to animals being in the shutdown zone, they must be allowed to remain in the zone until they leave of their own accord (NMFS 2020e), and work must not restart until they have been gone from the area for 30 minutes.

6.9.2. Observations during Marine Transit

Vessels transiting from Dutch Harbor to the Alaska North Slope may need to pass though critical habitat for North Pacific right whales. Other endangered whale species, such as sei and fin whales, could be encountered during the transit. Special measures are required for all vessel transiting though the North Pacific right whale critical habitat including the potential need for a dedicated observer (see Sections 6.13.1 and 6.13.2 for special requirements related to observations from vessels and observations in the marine transit route).

6.9.3. Observations during Project Activities

Observations by PSOs are crucial for implementing many of the mitigation measures described in this chapter, including but not limited to, shutdown and power down measures. During project activities, PSOs monitor the disturbance, safety, and exclusion zones for marine mammals and implement shutdown or delay procedures when applicable through communication with the equipment operator or vessel captain (see Sections 6.7 and 6.8). The ability of PSOs to effectively monitor safety and exclusion zones depends on their experience, state of alertness, visibility, and size of the zone. The height of the observation platform above water also directly affects distances out to which observers can detect marine mammals.

Prior to restarting seismic surveys, PSOs monitor for 15 minutes for pinnipeds and 30 minutes for cetaceans before reinitiating airguns (NMFS 2014a). This also applies to anchor handling work and pile driving (NMFS 2016e, a, 2020e). In the event of a delay or shutdown of activity due to animals being in the shutdown zone, they must be allowed to remain in the zone until they leave of their own accord and work may not start again until they have been gone for at least 30 minutes. The PSO must record all observations and presence of marine mammals along with activities occurring at the time of observation (NMFS 2020e).

6.10. Ramp Up and Soft Start

A ramp up of an energy source array provides a gradual increase in energy levels, and involves a step-wise increase in the number and total volume of energy released until the full complement is achieved (NMFS 2016f). The purpose of a ramp up (or ‘‘soft start’’) is to ‘‘warn’’ marine mammals in the vicinity of the energy source by providing a gradual increase of sound so they have the opportunity to move away and thus, avoid potential injury or impairment of their hearing abilities (NMFS 2009).

Pile-driving ramp up requires enacting an initial set of strikes at reduced energy, followed by a 30-second waiting period, then two subsequent reduced energy strike sets (NMFS 2020e). A ramp up or soft start must be implemented at the start of each day's activity driving and at any time following cessation of impact pile-driving for a period of 30 minutes or longer. For seismic surveys, the operator is required to ramp up energy sources slowly, if the energy source being utilized generates sound energy within the frequency spectrum of cetacean or pinniped hearing. Full ramp ups (*i.e.*, from a cold start after a shutdown, when no airguns have been firing) shall begin by firing one small airgun sometimes called a “mitigation airgun” (NMFS 2013a). Ramp ups are required at any time electrical power to the airgun array has been discontinued for a period of 10 minutes or more and the PSO watch has been suspended (NMFS 2009, 2014e, 2015d).

6.11. Speed Limits

Speed limits for both vehicles and vessels are often enforced to protect marine mammals from injury or death due to collisions or entanglement. Vessel speed limits are discussed in Section 6.13.1. The final rule for taking marine mammals incidental to ice roads and ice trails (NMFS 2020c) states that speed limits on ice roads and trails will be no greater than 74.5 km per hour under typical circumstances and may be exceeded in an emergency. The rule also states that vehicles will not stop within 50 m of identified seals or within 150 m of known seal lairs.

6.12. Waste Streams

6.12.1. Trash Management

BSEE regulations at 30 CFR §§ 250.300(a) and (b)(6) prohibit lessees from deliberately discharging containers and other similar materials (*i.e.*, trash and debris) into the marine environment. Additionally, the intentional jettisoning of trash has been prohibited by MARPOL Annex V and the Marine Plastic Pollution Research and Control Act, and regulations imposed by agencies including the USCG and the USEPA.

Certain USCG and USEPA regulations further require that lessees become more proactive in avoiding accidental loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins. Hilcorp Alaska LLC and Harvest Pipeline (2019) outlines food and waste management policies to protect polar bears.

6.12.2. Effluent Discharge

All effluent discharges must comply with APDES regulations (BOEMRE 2011; BOEM 2016; NMFS 2016f). In 2012, Shell, working with the AEWC, agreed to a zero discharge policy in the Beaufort Sea, keeping muds and cuttings contained and recycling them instead of discharging them into the ocean (BOEM 2015a). See Section 6.12.3 for more information on drilling mud disposal.

6.12.3. Drilling Muds

Not all types of drilling muds are allowed to be discharged. Many synthetic muds, including those that are oil-based, may not be discharged to the sea floor. These must be hauled away or be placed in a disposal well. Therefore, to the extent practicable based on operational considerations (*e.g.*, whether mud properties have deteriorated to the point where they cannot be used further), all drilling muds should be recycled (NMFS 2012k, 2016f). Shell (2011) and NMFS (2012k) state specifically that drilling muds would be cooled to mitigate potential permafrost thawing or thermal dissociation of any methane hydrates encountered during drilling, if such materials are present at the drill site.

6.13. Vessel Management

6.13.1. Vessel Speed, Direction and Behavior

To avoid disturbing marine mammals during vessel transit or during vessel-based oil and gas operations (*i.e.*, seismic, geophysical or drilling), vessels will reduce speed when within 274 m of marine mammals, avoid separating members from a group, and avoid multiple changes of direction (NMFS 2012k).

Guidelines for certain vessel behaviors have been identified to protect marine mammals. For example, BLM (2019) states that vessels stay at least 300 m away from cow-calf pairs, feeding aggregations, or whales that are engaged in breeding behavior. If the vessel is approached by cow-calf pairs, it will remain out of gear as long as whales are within 300 m of the vessel (consistent with safe operations).

In addition, NMFS marine mammal viewing guidelines[22] require that operators of vessels avoid approaching whales within 91 m and seals and sea lions within 46 m. Operators shall observe direction of travel and attempt to maintain a distance of 91 m or greater between the animal and the vessel by working to alter course or slowing the vessel. For in-water heavy machinery work other than pile-driving, if a marine

[22] https://www.fisheries.noaa.gov/topic/marine-life-viewing-guidelines; (Accessed August 2, 2021)

mammals comes within 10 m, operations shall cease and vessels shall reduce speed to the minimum level to allow steering (NMFS 2020a).

Vessels should remain anchored when approached by marine mammals to avoid an avoidance reaction, and observers should check waters adjacent to vessels prior to engaging propellers so that no whales are injured when they are engaged. Vessel speed is also to be reduced during inclement weather conditions to avoid collisions with marine mammals.

Specific requirements for avoiding Pacific walrus, polar bears, sea lions, spotted seals, and sea otters have also been identified (BOEM 2018; BLM 2019; Hilcorp Alaska LLC and Harvest Pipeline 2019). Vessel operators should reduce speed or change course to maintain a minimum operational exclusion zone of 0.8 km around groups of feeding walruses. Except in an emergency, vessel operators should not approach within 0.8 km of polar bears and walrus on ice, or within 1.6 km of walrus on land. According to USFWS (2014e), vessel operators must maintain a distance of 100 m from all sea otters when practicable.

Specifically for polar bears, operational and support vessels must be staffed with dedicated PSOs to alert crew of the presence of polar bears and initiate mitigation responses. Vessels must remain as far away as possible from concentrations of polar bears. No vessel should approach within 0.8 km of polar bears observed on land or ice. Vessels must avoid areas of active or anticipated polar bear subsistence hunting activity as determined through community consultations. The USFWS may require trained marine mammal monitors on the site of the activity or on board any vessel or vehicles to monitor the impacts of industry's activity on polar bear (BLM 2019).

Vessels must maintain a 1.6-km buffer from shore when passing aggregation of seals (primarily spotted seals) hauled out on land, unless doing so would endanger human life or violate safe boating practices. Vessels will remain 5.5 km from all Steller sea lion rookery sites (Figure 6-2) listed in 50 CFR § 224.103 (d)(1)(iii). The vessel operator will not purposely approach within 5.5 km of any major Steller sea lion rookery or haulout, unless doing so is necessary to maintain safe conditions (BLM 2019).

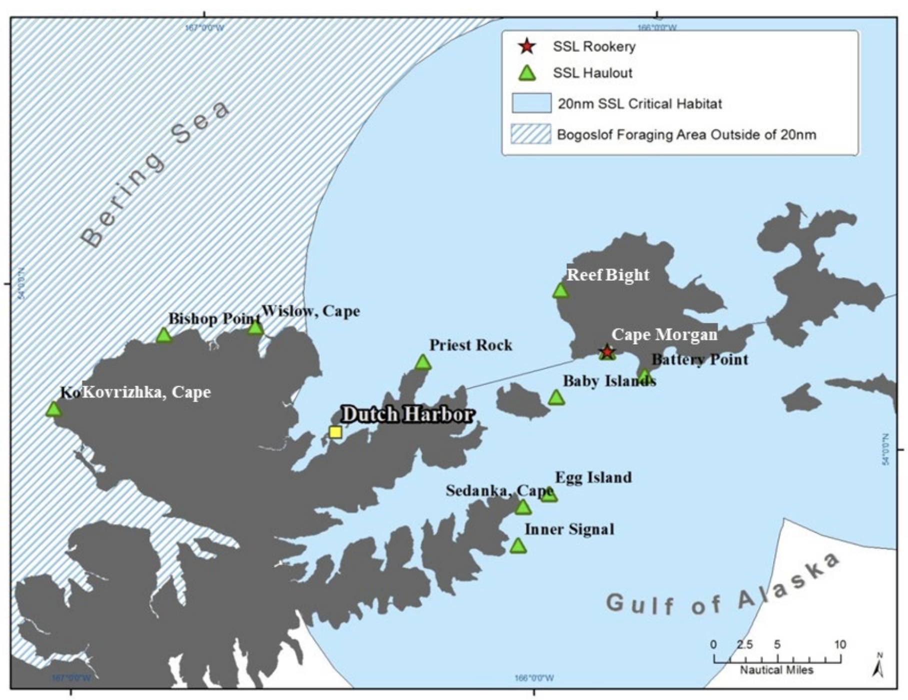

Figure 6-2. Steller Sea Lion Rookeries in the Vicinity of Dutch Harbor.

6.13.2. Transit Routes

Major oil and gas projects on the Alaska North Slope require that materials be brought north by vessels from Dutch Harbor or points further south through the Bering Strait. While transiting this route, special consideration must be given to North Pacific right whales and their critical habitat (BOEM 2018; BLM 2019; FERC 2019; BLM 2020a, b). Vessel operators are required to make every effort to avoid transit through North Pacific right whale critical habitat, but if this cannot be avoided, operators must post a dedicated PSO on the bridge and reduce speed to 10 kts while in the North Pacific right whale critical habitat. Alternately, vessels may transit at no more than 5 kts without the need for a dedicated PSO. In addition, vessels must remain at least 800 m from all North Pacific right whales and avoid approaching whales head-on, consistent with vessel safety. Operators must also maintain a ship log indicating the time and geographic coordinates at which vessels enter and exit North Pacific right whale critical habitat. As described in Section 6.3.2, transit north through the Bering Strait is not authorized prior to July 1st, and vessels must exit no later than November 15th.

6.14. Uncrewed Aircraft Systems

UAS (previously referred to as "Unmanned" Aircraft Systems) can be used to document the presence and quantity of marine mammals in a given area (Koski *et al.* 2009; Bryson and Williams 2015). They can also be used to assist PSOs in monitoring very large safety or disturbance zones (Fairweather Science LLC 2018; NMFS 2019c). UAS' can provide a safe method for studying or monitoring remote or otherwise inaccessible areas (Klemas 2015). Using a UAS in marine mammal ecology and management studies may decrease risk to personnel, increase survey efficiency, and minimize disturbance to wildlife (Ferguson *et al.* 2018). However, weather and sea state conditions can limit the use and effectiveness of UAS (Koski *et al.* 2009). Importantly, both environmental and flight-related variables with UAS directly affect the detectability of marine mammals and must be accounted for if using such technology (Aniceto *et al.* 2018). Increasing sea state, glare, and luminance may have positive or negative effects on detectability, and according to Aniceto *et al.* (2018), may depend on which species is observed. For example, a study conducted in Norway reported 57 harbor porpoise sightings, none of which were affected by sea state, glare, or luminance. However, during this same study, these factors had a negative effect on detecting humpback and killer whales (Aniceto *et al.* 2018).

A UAS consists of multiple parts including the uncrewed aerial vehicle, the sensor, or the ground control station (Klemas 2015). The two most common types of UAS used are fixed-wing systems and vertical takeoff and landing (VTOL) systems. VTOL systems range from nano-aircraft to larger uncrewed helicopters; they can have from three to eight propellers. Fixed-wing systems are usually larger than a VTOL unit, and have the ability to fly higher and faster than VTOL systems.

UAS come in various sizes and designs depending on the intended use. Marine mammal monitoring using UAS would require a MMPA authorization from NMFS or USFWS. NOAA's Uncrewed Systems Research Transition Office webpage[23] provides information on NOAA's UAS policies, program guidance, measures to protect marine mammals, and permits for research using small UAS. Within the context of the MMPA and ESA, NOAA's policies on the management and utilization of aircraft were developed to adhere to Federal Aviation Administration (FAA) requirements at 14 CFR Part 107 and NOA 216-104A (NOAA 2015). The 2020 FAA rule (14 CFR Part 107) covers a broad spectrum of commercial and government uses for drones weighing less than 24.9 kilograms (kg). Depending on the intended use of the UAS and considering the marine mammals and other protected species that may occur in the area (*i.e.*, birds), USFWS or NMFS may specify the altitude(s) at which a UAS is operated on a project-specific basis.

[23] https://uas.noaa.gov/; (Accessed August 16, 2021)

UAS operational considerations include Fairweather Science LLC (2018):

- Maintaining an elevation that will not result in disturbance of marine mammals (Rhodes and Spiegel 2017);
- If used to monitor safety zones, launching and recovering of UAS must be coordinated with the construction manager and lead PSO;
- Pilots must coordinate with other airspace operators (including but not limited to the FAA and local airports) to avoid collisions; and
- Coordination should include providing a flight plan detailing operational procedures, permit stipulations, recovery procedures in the event of a failure or unplanned water landing, and other safety procedures.

References – Volume 1 (Chapters 1 – 6)

Abadi, S. H., M. Tolstoy and W. S. D. Wilcock (2017). "Estimating the location of baleen whale calls using dual streamers to support mitigation procedures in seismic reflection surveys." PLoS ONE **12**(2): e0171115.

ABSG Consulting Inc. (2018). BOEM OCS Spill Statistics Report FINAL BOEM-2018-006, U.S. Dept. of Interior, Bureau of Ocean Energy Management: 44 pp.

ADNR (2001a). Beaufort Sea Areawide 2001 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 12 pp.

ADNR (2001b). Cook Inlet Areawide 2001 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 11 pp.

ADNR (2002a). Beaufort Sea Areawide 2002 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 12 pp.

ADNR (2002b). Cook Inlet Areawide 2002 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 11 pp.

ADNR (2003a). Beaufort Sea Areawide 2003 Competitive Oil and Gas Lease Sale; Mitigation Measures and Lessee Advisories, Alaksa Department of Natural Resources: 12 pp.

ADNR (2003b). Cook Inlet Areawide 2003 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 11 pp.

ADNR (2004). Cook Inlet Areawide 2004 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 15 pp.

ADNR (2007). Beaufort Sea Areawide 2007 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 14 pp.

ADNR (2008). Beaufort Sea Areawide 2008 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 11 pp.

ADNR (2010). Beaufort Sea Areawide 2010 Competitive Oil and Gas Lease Sale: Mitigation Measures and Other Regulatory Requirements (Lessee Advisories), Alaska Department of Natural Resources: 17 pp.

ADNR (2012). Cook Inlet Areawide 2012 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 9 pp.

ADNR (2013). Beaufort Sea Areawide 2013 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 12 pp.

ADNR (2014). Beaufort Sea Areawide 2014 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 12 pp.

ADNR (2015). Beaufort Sea Areawide 2015 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 12 pp.

ADNR (2016). Beaufort Sea Areawide 2016 Competitive OIl and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources: 11 pp.

ADNR (2017). Cook Inlet Areawide 2017 Competitive Oil and Gas Lease Sale: Mitigation Measures and Lessee Advisories, Alaska Department of Natural Resources**:** 9 pp.

ADNR (2018). Cook Inlet areawide Oil and Gas Lease Sale: Written Finding of the Director. Anchorage, AK, Alaska Department of Natural Resources**:** 303 pp.

ADNR (2019). Beaufort Sea areawide oil and gas lease sales: Final finding of the director. Anchorage, AK, Alaska Department of Natural Resources**:** 342 pp.

Aerts, L. A. M. and W. J. Richardson (2008). Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2007: Annual Summary Report., BP Exploration (Alaska) Inc.**:** 79 pp.

Aerts, L. A. M. 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, BP Exploration (Alaska) Inc.**:** 144 pp.

Aerts, L. A. M. 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, BP Exploration (Alaska) Inc.**:** 152 pp.

AEWC (2011). Programmatic Conflict Avoidance Agreement 2011 Open Water Season, Alaska Eskimo Whaling Commission**:** 51 pp.

Aniceto, A., M. Biuw, U. Lindstrøm, S. A. Solbø, F. Broms and J. Carroll (2018). "Monitoring marine mammals using unmanned aerial vehicles: quantifying detection certainty." Ecosphere **9**(3): 15 pp.

Arctic Oil Spill Response Technology Joint Industry Programme (2017). Arctic Oil Spill Resposne Technology Joint Industry Programme Summary Report. Arctic Response Technology Oil Spill Preparedness**:** 16 pp.

Ashjian, C. J., S. R. Braund, R. G. Campbell, J. C. C. George, J. Kruse, W. Maslowski, S. E. Moore, C. R. Nicolson, S. R. Okkonen, B. F. Sherr, E. B. Sherr and Y. H. Spitz (2010). "Climate Variability, Oceanography, Bowhead Whale Distribution, and Iñupiat Subsistence Whaling near Barrow, Alaska." Arctic **63**(2): 171-194.

Austin, M. (2017). Acoustic Monitoring of a Gas Pipeline Leak and Repair Activities, Middle Ground Shoal, Cook Inlet, Alaska**:** 32 pp.

Banet Jr., A. C. (1991). Oil and Gas Development on Alaska's North Slope: Past Results and Future Prospects**:** 40 pp.

Bejder, L., A. Samuels, H. Whitehead, H. Finn and S. Allen (2009). "Impact assessment research: use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli." Marine Ecology Progress Series **395**: 177-185.

Bisson, L. N., H. J. Reider, H. M. Patterson, M. Austin, J. R. Brandon, T. Thomas and M. L. Bourdon (2013). Marine Mammal Monitoring and Mitigaiton During Exploratory Drilling by Shell in the Chukchi and Beaufort Seas, July-November 2012: Draft 90-Day Report, Shell Offshore Inc**:** 290 pp.

Blackwell, S. B., W. C. Burgess, K. H. Kim, R. G. Norman, C. R. Greene Jr, M. W. McLennan and L. A. M. Aerts (2009). "Sounds recorded at Northstar and in the offshore DASAR array, autumn 2008 " LGL Report **1081**.

Blackwell, S. B. and C. R. Greene Jr. (2006). "Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels." Journal of Acoustical Society of America **119**(1): 182-196.

Blackwell, S. B., C. R. Greene Jr. and W. J. Richardson (2004a). "Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea." Journal of the Acoustical Society of America **116**(5): 3199-3211.

Blackwell, S. B., J. W. Lawson and M. T. Williams (2004b). "Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island." Journal of the Acoustical Society of America **115**(5 Pt 1): 2346-2357.

Blackwell, S. B., C. S. Nations, T. L. McDonald, A. M. Thode, D. Mathias, K. H. Kim, C. R. Greene and A. M. Macrander (2015). "Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds." PLoS ONE **10**(6): e0125720.

Blackwell, S. B. and A. M. Thode (2021). Chapter 35 - Effects of Noise. The Bowhead Whale *Balaena mysticetus*. J. C. George and J. G. M. Thewissen, Academic Press**:** 565-576.

Blackwell, S. B., A. M. Thode, A. S. Conrad, M. C. Ferguson, C. L. Berchok, K. M. Stafford, T. A. Marques and K. H. Kim (2021). "Estimating acoustic cue rates in bowhead whales, *Balaena mysticetus*, during their fall migration through the Alaskan Beaufort Sea." Journal of the Acoustical Society of America **149**(5): 3611.

BLM (2019). Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program, Final Environmental Impact Statement and Record of Decision. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Land Management. **Vol. 1-3:** 515 pp + appendices.

BLM (2020a). National Petroleum Reserve in Alaska, Integrated Activity Plan and Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Land Management. **Vol 1-3:** 558 pp + appendices.

BLM (2020b). Willow Master Development Plan, Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Land Management. **Vol. 1-7:** 393 pp + appendices.

BOEM (2012a). ION Geophysical 2012 Seismic Survey Beaufort Sea and Chukchi Sea, Alaska, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 102 pp.

BOEM (2012b). "Special Issue on Traditional Knowledge." BOEM Ocean Science **9**(2): 3-15.

BOEM (2013). TGS 2013 Geophysical Seismic Survey Chukchi Sea, Alaska, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 110 pp.

BOEM (2014a). SAExploration, Inc. Colville River Delta 2014 3D Geophysical Seismic Survey Beaufort Sea, Alaska, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 135 pp.

BOEM (2014b). SAExporation, Inc. 2014 Geophysical Seismic Survey, Beaufort Sea Alaska, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 68 pp.

BOEM (2015a). Chukchi Sea Planning Area Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska, Final Second Supplemental Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management. **Vol. 1-2:** 1596 pp.

BOEM (2015b). SAExploration, Inc. 3D Cook Inlet 2015 Geological and Geophysical Seismic Survey, Lower Cook Inlet, Alaska, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 98 pp.

BOEM (2015c). Shell Gulf of Mexico, Inc. Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska Revision 2, Environmental Assessment, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 276 pp.

BOEM (2016). Cook Inlet Planning Area Oil and Gas Lease Sale 244 in the Cook Inlet, Alaska Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management. **Vol. 1:** 832 pp.

BOEM (2017). Eni U.S. Operating Company Inc. Outer Continental Shelf Lease Exploration Plan Harrison Bay Block 6423 Unit - Leases OCS-Y-1753, OCS-Y-1754, and OCS-Y-1757, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 181 pp.

BOEM (2018). Liberty Development and Production Plan, Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management. **Vol. 1-2:** 621 pp + appendices.

BOEM (2019). USDOI, BOEM Oil Spill Preparedness, Prevention, and Response on the Alaska OCS. OCS Report BOEM 2019-006. Anchorage, AK, U.S. Dept. of Interior, Bureau of Ocean Energy Management**:** 41 pp.

BOEMRE (2011). Beaufort Sea Planning Area, Shell Offshore Inc. 2012 Revised Outer Continental Shelf Lease Exploration Plan Camden Bay, Beaufort Sea, Alaska, Flaxman Island Blocks 6559, 6610 & 6658, Beaufort Sea Lease Sales 195 & 202, Environmental Assessment. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management Regulation and Enforcement**:** 238 pp.

Bonnel, J., B. Kinda and D. P. Zitterbart (2021). "Low Frequency Ocean Ambient Noise on the Chukchi Shelf in the Changing Arctic." Journal of Acoustical Society of America **149**(2): 13 pp.

BP Exploration Alaska (2009). "Request for LOA BPXA Northstar Operation of Offshore Oil and Gas Facilities in the U.S. Beaufort Sea." 113 pp.

Braund, S. R. and J. Kruse (2009). Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska. Anchorage, AK, U.S. Dept. of the Interior, Minerals Management Service**:** 462 pp.

Bryson, M. and S. Williams (2015). Review of Unmanned Aerial Systems for Marine Surveys. Sydney, Australia, Australian Centre for Field Robotics, University of Sydney**:** 24 pp.

Burek Huntington, K. A., V. A. Gill, A. M. Berrian, T. Goldstein, P. Tuomi, B. A. Byrne, K. Worman and J. Mazet (2021). "Causes of Mortality of Northern Sea Otters (*Enhydra lutris kenyoni*) in Alaska From 2002 to 2012." Frontiers in Marine Science **8**(105).

Burns, J. J. and S. J. J. Harbo (1972). "An Aerial Census of Ringed Seals, Northern Coast of Alaska." Arctic **25**(4): 279-290.

Carretta, J. V., J. Barlow and L. Enriquez (2008). "Acoustic pingers eliminate beaked whale bycatch in a gill net fishery." Marine Mammal Science **24**: 956-962.

Castellote, M. (2019). Harvest's Cook Inlet Pipeline (CIPL) Extension Project Acoustic Monitoring: Final Report. Seattle, WA, University of Washington, NOAA Fisheries, Joint Institute for the Study of the Atmosphere and Ocean**:** 33 pp.

Castellote, M., M. Stocker and A. Brewer (2020). Passive Acoustic Monitoring of Cetaceans and Noise During Hilcorp 3D Seismic Survey in Lower Cook Inlet, AK. Final Report.**:** 24 pp.

Castellote, M., B. Thayre, M. Mahoney, J. Mondragon, M. O. Lammers and R. J. Small (2019). "Anthropogenic Noise and the Endangered Cook Inlet Beluga Whale, *Delphinapterus leucas*: Acoustic Considerations for Management." Marine Fisheries Review **80**(3): 63-88.

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.

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. NOAA Technical Memorandum, National Marine Fisheries Service**:** 86 pp.

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.

Ellison, W. T., R. Racca, C. W. Clark, B. Streever, A. S. Frankel, E. Fleishman, R. Angliss, J. Berger, D. Ketten, M. Guerra, M. Leu, M. McKenna, T. Sformo, B. Southall, R. Suydam and L. Thomas (2016). "Modeling the aggregated exposure and responses of bowhead whales *Balaena mysticetus* to multiple sources of anthropogenic underwater sound." Endangered Species Research **30**(1): 95-108.

Ellison, W. T., B. L. Southall, A. S. Frankel, K. Vigness-Raposa and C. W. Clark (2018). "An Acoustic Scene Perspective on Spatial, Temporal, and Spectral Aspects of Marine Mammal Behavioral Responses to Noise." Aquatic Mammals **44**(3): 239-243.

EPA (1999). Consideration of Cumulative Impacts in EPA Review of NEPA Documents, U.S. Environmental Protection Agency, Office of Federal Activities**:** 22 pp.

Fairweather Science, L. (2020). 2019 Hilcorp Alaska Lower Cook Inlet Seismic Survey Marine Mammal Monitoring and Mitigation Report. , Hilcorp Alaska, LLC**:** 238 pp.

Fairweather Science LLC (2018). CIPL Extension Project: Marine Mammal Monitoring and Mitigation Plan (Revised), Harvest Alaska LLC**:** 15 pp.

FERC (2019). Alaska LNG Project, Draft Environmental Impact Statement. Washington, DC, Federal Energy Regulatory Commission. **Vol. 1-3:** 495 pp + appendices.

Ferguson, M. C., R. P. Angliss, A. Kennedy, B. Lynch, A. Willoughby, V. Helker, A. A. Brower and J. T. Clarke (2018). "Performance of Manned and Unmanned Aerial Surveys to Collect Visual Data and Imagery for Estimating Arctic Cetacean Density and Associated Uncertainty (DRAFT)." Journal of Unmanned Vehicle Systems: 58 pp.

Ferrara, G. A. (2017). Assessing the Vulnerability of Marine Mammal Subsistence Species in the Bering Sea to Climate Change. Seattle, WA, University of Washington. **Thesis: Master of Marine Affairs:** 35 pp.

Finneran, J. J. (2015). "Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015." Journal of the Acoustical Society of America **138**(3): 1702-1726.

Finneran, J. J. and B. K. Branstetter (2013). Effects of Noise on Sound Perception in Marine Mammals. Animal Communication and Noise**:** 273-308.

Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder and S. H. Ridgway (2002). "Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun." Journal of the Acoustic Society of America **111**(6): 2929-2940.

Fleishman, E., D. P. Costa, J. Harwood, S. Kraus, D. Moretti, L. F. New, R. S. Schick, L. K. Schwarz, S. E. Simmons, L. Thomas and R. S. Wells (2016). "Monitoring population-level responses of marine mammals to human activities." Marine Mammal Science **32**(3): 1004-1021.

Frost, K. J. and J. J. Burns (1989). Winter ecology of ringed seals (*Phoca hispida*) in Alaska. Minerals Management Service, NOAA Contract No. NA-81-RAC-00045, Final Report 1 January 1981-31 December 1984, Alaska Department of Fish and Game, Division of Game, Fairbanks. Fairbanks, AK, Minerals Management Service and National Oceanic and Atmospheric Administration**:** 116 pp.

Funk, D. W., D. S. Ireland, R. Rodrigues and W. R. Koski (2010). Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008, Shell Offshore, Inc., ConocoPhillips Alaska, Inc., Eni U.S. Operating Co., Inc. and other Industry Contributors**:** 499 pp.

Grebmeier, J. M., L. W. Cooper, C. A. Ashjian, B. A. Bluhm, R. B. Campbell, K. E. Dunton, J. Moore, S. Okkonen, G. Sheffield, J. Trefry and S. Y. Pasternak (2015). "Pacific Marine Arctic Regional Synthesis (PacMARS) Final Report. North Pacific Research Board." 263 pp.

Greene, C. and W. Richardson (1988). "Characteristics of marine seismic survey sounds in the Beaufort Sea." Journal of the Acoustical Society of America **83**: 2246-2254.

Greene, C. R., Jr., S. B. Blackwell and M. W. McLennan (2008). "Sounds and vibrations in the frozen Beaufort Sea during gravel island construction." Journal of the Acoustical Society of America **123**(2): 687-695.

Greene, C. R., Jr., M. W. McLennan, R. G. Norman, T. L. McDonald, R. S. Jakubczak and W. J. Richardson (2004). "Directional frequency and recording (DIFAR) sensors in seafloor recorders to locate calling bowhead whales during their fall migration." Journal of the Acoustical Society of America **116**(2): 799-813.

Greene, C. R. J. (1987). Acoustic studies of underwater noise and localization of whale calls. Sect. 2 In: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA; 1987. Report for Shell Western E & P Inc., Anchorage, AK. **:** 128 pp.

Greeneridge Sciences Inc. (2017). Northstar Near-island Sound Levels, 2001–2016, Report prepared for Hilcorp Alaska LLC**:** 6 pp.

Haley, B., D. S. Ireland and J. R. Childs (2010). Environmental Assessment for a Marine Geophysical Survey of Parts of the Arctic Ocean, August-September 2010, U.S Dept. of the Interior, U.S. Geological Survey**:** 261 pp.

Halliday, W. D., M. K. Pine and S. J. Insley (2020). "Underwater noise and Arctic marine mammals: review and policy recommendations." Environmental Reviews **11**: 44 pp.

Hawkins, A. D., R. A. Hazelwood, A. N. Popper and P. C. Macey (2021). "Substrate vibrations and their potential effects upon fishes and invertebrates." Journal of the Acoustical Society of America **149**(4): 2782.

Hilcorp Alaska LLC (2015). Plan of Cooperation: Liberty Unit Shallow Geohazard Surveys, Beaufort Sea, Alaska 2015**:** 165 pp.

Hilcorp Alaska LLC and Harvest Pipeline (2019). Bear Interaction, Mitigation, and Monitoring Plan for Hilcorp Alaska, LLC. Areas of Operation, North Slope, Alaska and Kenai and Cook Inlet Facilities, Hilcorp Alaska LLC. and Harvest Pipeline**:** 51 pp.

Huntington, H. P. (2009). "A preliminary assessment of threats to Arctic marine mammals and their conservation in the coming decades." Marine Policy **33**(1): 77-82.

Huntington, H. P., L. T. Quakenbush and M. Nelson (2016). "Effects of changing sea ice on marine mammals and subsistence hunters in northern Alaska from traditional knowledge interviews." Biology Letters **12**: 20160198.

IMO (1992). Annex I Regulation 19 - Double hull and double bottom requirements for oil tankers delivered on or after 6 July 1996, International Maritime Organization**:** 4 pp.

IPCC (2014). Climate Change 2014 Synthesis Report. R. K. Pachauri and L. A. Meyer. Geneva, Switzerland, Intergovernmental Panel on Climate Change**:** 151 pp.

Ireland, D. S., L. Bisson, S. B. Blackwell, M. Austin, D. E. Hannay, K. Bröker and A. M. Macrander (2016). Comprehensive Report of Marine Mammal Monitoring and Mitigation in the Chukchi and Beaufort Seas, 2006–2015., National Marine Fisheries Service, U.S. Fish and Wildlife Service**:** 558 pp + appendices.

Jay, C. V., M. S. Udevitz, R. Kwok, A. S. Fischbach and D. C. Douglas (2010). "Divergent movements of walrus and sea ice in the northern Bering Sea." Marine Ecology Progress Series **407**: 293-302.

Johnston, D. W. (2002). "The effect of acoustic harassment devices on harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada." Biological Conservation **108**: 113-118.

Kastak, D. R., B. L. Southall, R. J. Schusterman and C. R. Kastak (2005). "Underwater temporary threshold shifts in pinnipeds: effects of noise level and duration." Journal of the Acoustical Society of America **118**: 3154-3163.

Kastelein, R. A., P. Mosterd, B. van Santen, M. Hagedoorn and D. de Haan (2002). "Underwater audiogram of a Pacific walrus (*Odobenus rosmarus divergens*) measured with narrow-band frequency-modulated signals." Journal of the Acoustic Society of America **112**: 2173-2182.

Kastelein, R. A., H. T. Rippe, N. Vaughn, N. M. Schooneman, W. C. Verboom and D. DeHaan (2000). "The effects of acoustic alarms on the behavior of harbor porpoises (*Phocoena phocoena*) in a floating pen." Marine Mammal Science **16**: 18.

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 Pt 1): 1820-1829.

Kastelein, R. A., W. C. Verboom, N. Jennings and D. de Haan (2008a). "Behavioral avoidance threshold level of a harbor porpoise (*Phocoena phocoena*) for a continuous 50 kHz pure tone." Journal of the Acoustical Society of America **123**(4): 1858-1861.

Kastelein, R. A., W. C. Verboom, N. Jennings, D. de Haan and S. van der Heul (2008b). "The influence of 70 and 120 kHz tonal signals on the behavior of harbor porpoises (*Phocoena phocoena*) in a floating pen." Mar Environ Res **66**(3): 319-326.

Kim, K. H. and J. W. Richardson (2016). Monitoring of industrial sounds, seals, and bowhead whales near Hilcorp's Northstar Oil Development, Alaskan Beaufort Sea, 2015: Summary Report., Greeneridge Sciences Inc. and LGL Alaska Research Assoc. Inc. for Hilcorp Alaska LLC**:** 69 pp.

Kim, K. H. and J. W. Richardson (2020a). Monitoring of industrial sounds, seals, and bowhead whales near Hilcorp's Northstar Oil Development, Alaskan Beaufort Sea, 2017: Summary Report, Greeneridge Sciences Inc. and LGL Alaska Research Assoc. Inc. for Hilcorp Alaska, LLC**:** 75 pp.

Kim, K. H. and J. W. Richardson (2020b). Monitoring of industrial sounds, seals, and bowhead whales near Hilcorp's Northstar Oil Development, Alaskan Beaufort Sea, 2018: Summary Report, Greeneridge Sciences Inc. and LGL Alaska Research Assoc. Inc. for Hilcorp Alaska, LLC**:** 75 pp.

Klemas, V. V. (2015). "Coastal and Environmental Remote Sensing from Unmanned Aerial Vehicles: An Overview." Journal of Coastal Research **315**: 1260-1267.

Koski, W. R., T. Allen, D. Ireland, G. Buck, P. R. Smith, A. M. Macrander, M. A. Halick, C. Rushing, D. J. Sliwa and T. L. McDonald (2009). "Evaluation of an Unmanned Airborne System for Monitoring Marine Mammals." Aquatic Mammals **35**(3): 347-357.

Kovacs, K. M., C. Lydersen, J. E. Overland and S. E. Moore (2010). "Impacts of changing sea-ice conditions on Arctic marine mammals." Marine Biodiversity **41**(1): 181-194.

Laidre, K. L., I. Stirling, L. F. Lowry, W. Oystein and M. P. Heide-Jørgensen (2008). "Quantifying the Sensitivity of Arctic Marine Mammals to Climate-Induced Habitat Change." Ecological Applications **18**(2): S97–S125.

Levfevre, J. (2013). "A Pioneering Effort in the Design of Process and Law Supporting Integrated Arctic Ocean Management." Environmental Law Institute **43**(10): 16 pp.

LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. and Greeneridge Sciences Inc. (2014). Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors**:** 354 pp.

LGL Ltd. and Marine Acoustics Inc. (2011). Environmental Assessment of Marine Vibroseis. London, UK, Joint Industry Programme, E&P Sound and Marine Life, and the International Association of Oil & Gas Producers**:** 232 pp.

MacCracken, J. G., W. S. Beatty, J. L. Garlich-Miller, M. L. Kissling and J. A. Snyder (2017). Final Species Status Assessment for the Pacific Walrus (*Odobenus rosmarus divergens*). Anchorage, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 298 pp.

MacLean, S. A. (1998). Marine Mammal Monitoring of an On-Ice Seismic Program in the Eastern Alaskan Beaufort Sea, April 1998, Prepared for BP Exploration (Alaska) Inc.**:** 17 pp.

Matthews, M.-N. R., D. S. Ireland, D. G. Zeddies, R. H. Brune and C. D. Pyć (2020). "A Modeling Comparison of the Potential Effects on Marine Mammals from Sounds Produced by Marine Vibroseis and Air Gun Seismic Sources." Journal of Marine Science and Engineering **9**(1).

Michel, J. (2020). Oil Spill Effects Literature Study of Spills of Greater than 20,000 Barrels of Crude Oil, Condensate, or Diesel. Sterling, VA, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 236 pp.

Michel, J. (2021). Oil Spill Effects Literature Study of Spills of 500–20,000 Barrels of Crude Oil, Condensate, or Diesel. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 351 pp.

Miller, G. W., V. Moulton, R. A. Davis, M. Holst, P. Millman, A. Macgillivray and D. Hannay (2005). "Monitoring seismic effects on marine mammals-southeastern Beaufort Sea, 2001-2002." <u>Offshore Oil and Gas Environmental Effects Monitoring: Approaches and Technologies</u>: 511-542.

MMS (2000). Proceedings of the Beaufort Sea Information Update Meeting, U.S. Dept. of the Interior, Minerals Management Service. **2000-023:** 46 pp.

MMS (2002a). Liberty Development and Production Plan, Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Minerals Management Service. **Vol. 1-3:** 760 pp.

MMS (2002b). Outer Continental Shelf Oil & Gas Leasing Program 2002-2007, Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Minerals Management Service. **Vol. 1-2:** 615 pp.

MMS (2003a). Beaufort Sea Planning Area, Oil and Gas Lease Sales 186, 195, and 202, Final Environmental Impact Statement, U.S. Dept .of the Interior, Minerals Management Service. **Vol. 1:** 1597 pp.

MMS (2003b). Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199, Final Environmental Impact Statement. Anchorage, AK, U.S. Dept. of the Interior, Minerals Management Service**:** 702 pp.

MMS (2006). Final Programmatic Environmental Assessment, Arctic Ocean Outer Continental Shelf Seismic Surveys 2006. Anchorage, AK, U.S. Dept. of the Interior, Minerals Management Service**:** 305 pp.

MMS (2007a). Outer Continental Shelf Oil & Gas Leasing Program 2007-2012, Final Environmental Impact Statement, April 2007, U.S. Dept. of the Interior, Minerals Management Service**:** 210 pp + appendices.

MMS (2007b). Outer Continental Shelf Oil & Gas Leasing Program: Draft EIS Appendix C Mitigation Measures, U.S. Dept. of the Interior, Minerals Management Service**:** 8 pp.

MMS (2008). Beaufort Sea and Chukchi Sea Planning Areas, Oil and Gas lease Sales 209, 212, 217, and 221, Draft Environmental Impact Statement. Anchorage, AK, U.S. Dept of the Interior, Minerals Management Service. **Vol. 2-3:** 530 pp + appendices.

Moberg, G. P. (2000). Biological Response to Stress-Implications for Animal Welfare. <u>The Biology of Animal Stress</u>. G. P. Moberg and J. A. Mench, CAB International**:** 21 pp.

Moore, S. E. (2016). "Is it 'boom times' for baleen whales in the Pacific Arctic region?" <u>Biology Letters</u> **12**(9): 4 pp.

Moore, S. E. and H. P. Huntington (2008). "Arctic marine mammals and climate change: Impacts and resilience." <u>Ecological Applications</u> **18**(2): 157-165.

Moore, S. E. and P. J. Stabeno (2015). "Synthesis of Arctic Research (SOAR) in Marine Ecosystems of the Pacific Arctic." <u>Progress in Oceanography</u> **136**: 1-11.

Nachtigall, P. E., J. L. Pawloski and W. W. Au (2003). "Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (Tursiops truncatus)." <u>Journal of the Acoustical Society of America</u> **113**(6): 3425-3429.

Navy (2014). "Noise Levels of Underwater Tools." 8 pp.

Niemi, A., S. Ferguson, K. Hedges, H. Melling, C. Michel, B. Ayles, K. Azetsu-Scott, P. Coupel, D. Deslauriers, E. Devred, T. Doniol-Valcroze, K. Dunmall, J. Eert, P. Galbraith, M. Geoffroy, G. Gilchrist, H. Hennin, K. Howland, M. Kendall, D. Kohlbach, E. Lea, L. Loseto, A. Majewski, M. Marcoux, C. Matthews, D. McNicholl, A. Mosnier, C. J. Mundy, W. Ogloff, W. Perrie, Clark Richards, E. Richardson, J. Reist, V. Roy, C. Sawatzky, K. Scharffenberg, R. Tallman, J.-E. r. Tremblay, T. Tufts, C. Watt, W. Williams, E. Worden, D. Yurkowski and S. Zimmerman (2019). State of Canada's Arctic Seas, Fisheries and Oceans Canada**:** 206 pp.

NMFS (2000). "65 FR 34014 Final Rule Construction and Operation of Offshore Oil and Gas Facilities in the Beaufort Sea." Federal Register **65**(102): 34014-34032.

NMFS (2001). "66 FR 9291 IHA Phillips Oil and Gas Exploration Drilling Activities in the Beaufort Sea, Alaska." Federal Register **66**: 9291-9298.

NMFS (2002). "67 FR 77750 LOA BPXA Northstar Oil and Gas Production Beaufort Sea, Alaska." Federal Register **67**: 77750-77752.

NMFS (2003a). "68 FR 14401 IHA ConocoPhillips On-ice Seismic Activities, Beaufort Sea, Alaska." Federal Register **68**: 14401- 14408.

NMFS (2003b). "68 FR 47547 IHA EnCana Oil and Gas Movement of Steel Drilling Caisson through the Beaufort Sea from Cross Island, McCovey Prospect to Herschel Island, Yukon Territory." Federal Register **68**: 47547-47549.

NMFS (2004). "69 FR 10209 IHA ConocoPhillips On-Ice Seismic Cape Halkett to Oliktok Point." Federal Register **69**: 10209-10212.

NMFS (2005a). "70 FR 17066 IHA ConocoPhillips On-ice Seismic Operations in the Beaufort Sea, Alaska." Federal Register **70**: 10766-10768.

NMFS (2005b). "70 FR 47809 IHA FEX Movement of Barges Through the Beaufort Sea Between West Dock and Cape Simpson, Alaska." Federal Register **70**: 47809-47813.

NMFS (2006a). "71 FR 11314 Final Rule and LOA BPXA Northstar Operation of Offshore Oil and Gas Facilities in the Beaufort Sea, Alaska." US Federal Register **71**(44): 11314-11324.

NMFS (2006b). "71 FR 26336 IHA ASRC Harrison Bay Seismic." Federal Register **71**: 26336-26340.

NMFS (2006c). "71 FR 49418 IHA GXT Seismic Surveys in the Chukchi Sea off Alaska." Federal Register **71**: 49418-49433.

NMFS (2006d). Biological Opinion: MMS Oil and Gas Leasing and Exploration 2006 - 2013 in Beaufort and Chukchi Seas, Alaska, National Marine Fisheries Service**:** 108 pp.

NMFS (2007a). "72 FR 17842 IHA Shell On-Ice Marine Seismic Research & Development Beaufort Sea, Alaska." Federal Register **72**: 17842-17849.

NMFS (2007b). "72 FR 17864 Notice of Receipt of IHA Application Shell Seismic Surveys in the Beaufort and Chukchi Seas off Alaska." Federal Register **72**: 17864-17873.

NMFS (2007c). "72 FR 19695 IHA ConcoPhillips On-ice Geotechnical Operations in the Beaufort Sea." Federal Register **72**: 19695-19699.

NMFS (2007d). "72 FR 38065 LOA BPXA Northstar Construction and Operation of Offshore Oil and Gas Facilities in the Beaufort Sea, Alaska." Federal Register **72**: 38065-38067.

NMFS (2007e). "72 FR 45740 IHA FEX Movement of Barges Through the Beaufort Sea Between West Dock and Cape Simpson or Point Lonely, Alaska." Federal Register **72**: 45740-45744.

NMFS (2008a). "73 FR 9535 IHAs CGGVeritas and Shell On-ice Geophysical and Seismic Beaufort Sea, Alaska." Federal Register **73**: 9535-9544.

NMFS (2008b). "73 FR 36044 Notice of Receipt of IHA Application Shell and WesternGeco Seismic Surveys in the Beaufort and Chukchi Seas, Alaska." Federal Register **73**: 36044-36062.

NMFS (2008c). "73 FR 38990 LOA Northstar Construction and Operations Beaufort Sea." Federal Register **73**: 38990-38991.

NMFS (2008d). "73 FR 40512 IHA BPXA 3D OBC Seismic Survey in the Liberty Prospect, Beaufort Sea, Alaska." Federal Register **73**: 40512-40538.

NMFS (2008e). "73 FR 45969 IHA PGS Onshore Seismic Survey in the Beaufort Sea, Alaska, Summer and Early Fall 2008." Federal Register **73**: 45969-45994.

NMFS (2008f). "73 FR 49421 IHA ConocoPhillips Shallow Hazard and Site Clearance Surveys in the Chukchi Sea in 2008." Federal Register **73**: 49421-49443.

NMFS (2008g). "73 FR 77623 Notice of Proposed IHA CGGVeritas On-ice Marine Geophysical and Seismic Operations in State/OCS Waters of the U.S. Beaufort Sea off Alaska." Federal Register **73**: 77623-77630.

NMFS (2009). "74 FR 55368 IHA Shell Open-water Marine Survey Program in the Chukchi Sea, Alaska, During 2009– 2010." Federal Register **74**: 55368-55412.

NMFS (2010a). "75 FR 20482 Notice of Proposed IHA Shell Exploration Drilling Program Near Camden Bay, Beaufort Sea, Alaska." Federal Register **75**: 20482-20509.

NMFS (2010b). "75 FR 49710 IHA Shell Open Water Marine Seismic Survey in the Beaufort and Chukchi Seas, Alaska." Federal Register **75**: 49710-49758.

NMFS (2010c). "75 FR 60174 IHA USGS Marine Seismic Survey in the Arctic Ocean, August to September, 2010." Federal Register **75**: 60174-60203.

NMFS (2011a). "76 FR 20180 Final rule Endangered and Threatened Species: Designation of Critical Habitat for Cook Inlet Beluga Whale." Federal Register **76**(69): 20180-20214.

NMFS (2011b). "76 FR 46729 IHA Statoil Chukchi Shallow Hazards Survey." Federal Register **76**: 46729-46753.

NMFS (2012a). "77 FR 27322 IHA Shell Exploration Drilling Program in the Chukchi Sea, Alaska." Federal Register **77**: 27322-27356.

NMFS (2012b). "77 FR 27720 IHA Apache Seismic Survey in Cook Inlet, Alaska." Federal Register **77**: 27720-27736.

NMFS (2012c). "77 FR 40007 IHA BPXA Marine Seismic Survey in the Beaufort Sea, Alaska." Federal Register **77**: 40007-40023.

NMFS (2012d). "77 FR 65060 IHA ION In-Ice Marine Seismic Operations in Chukchi and Beaufort Seas, Alaska." Federal Register **77**: 65060-65090.

NMFS (2012e). Biological Opinion: BPXA Northstar Development Marine Mammal Protection Act Authorization 2012-2016, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 127 pp.

NMFS (2012f). Biological Opinion: IHA and Geological and Geophysical Permit to ION for 2012 2D Seismic Surveys in Chukchi and Beaufort Seas, Alaska, National Marine Fisheries Service**:** 159 pp.

NMFS (2012g). Biological Opinion: IHA BP Offshore, Inc. 2012 Seismic Surveys in Simpson Lagoon, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 136 pp.

NMFS (2012h). Biological Opinion: IHA Shell Offshore, Inc. 2012 Exploratory Drilling in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 108 pp.

NMFS (2012i). Biological Opinion: IHA Shell Offshore, Inc. 2012 Exploratory Drilling in Chukchi Sea, Alaska, National Marine Fisheries Service**:** 119 pp.

NMFS (2012j). Environmental Assessment for Rulemaking and Letters of Authorization to BP Exploration (Alaska) Inc. for the Take of Marine Mammals Incidental to Operation of Offshore Oil and Gas Facilities in the U.S. Beaufort Sea. Silver Spring, MD, National Marine Fisheries Service**:** 177 pp.

NMFS (2012k). Final Environmental Assessment for IHA to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. Silver Spring, MD, National Marine Fisheries Service**:** 262 pp.

NMFS (2012l). Revised Biological Opinion: Apache 3D Seismic Surveys in Cook Inlet, Alaska, National Marine Fisheries Service**:** 131 pp.

NMFS (2013a). "78 FR 12720 IHA Apache Seismic Survey in Cook Inlet, Alaska." Federal Register **78**: 12720-12744.

NMFS (2013b). "78 FR 75488 Final Rule BPXA Northstar LOA Operation 2014 - 2019, Beaufort Sea " Federal Register **78**: 75488-75510.

NMFS (2013c). Biological Opinion: BOEM and BSEE Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska, National Marine Fisheries Service**:** 527 pp.

NMFS (2013d). Biological Opinion: IHA SAExploration, Inc. 2013 Marine 3D Ocean Bottom Cable Seismic Activities in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 246 pp.

NMFS (2013e). Biological Opinion: Re-initiation of Section 7 Consultation Apache 3D Seismic Surveys of Cook Inlet, Alaska, National Marine Fisheries Service**:** 137 pp.

NMFS (2013f). Environmental Assessment for the Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open-Water Marine and Seismic Surveys in The Beaufort and Chukchi Seas. Silver Spring, MD, National Marine Fisheries Service**:** 206 pp.

NMFS (2014a). "79 FR 36730 IHA BPXA 3D Seismic Survey in Prudhoe Bay, Beaufort Sea, Alaska." Federal Register **79**: 36730-36743.

NMFS (2014b). "79 FR 36769 IHA BPXA Geohazard Foggy Island Bay Beaufort Sea, Alaska." Federal Register **79**: 36769-36782.

NMFS (2014c). Biological Opinion: IHA BPXA Shallow Geohazard Survey in Foggy Island Bay, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 139 pp.

NMFS (2014d). Environmental Assessment for the Issuance of Incidental Harassment Authorizations to BP Exploration (Alaska) Inc. for the Take of Marine Mammals Incidental to Seismic and Geohazard Surveys in the Beaufort Sea, Alaska. Silver Spring, MD, National Marine Fisheries Service**:** 52 pp.

NMFS (2014e). IHA SAExploration 3D OBN Seismic Surveys and Related Activities in the Beaufort Sea, Alaska. Silver Spring, MD, National Marine Fisheries Service**:** 18 pp.

NMFS (2014f). "Letter of Authorization: Northstar Facility in the Central Beaufort Sea, Alaska." 10 pp.

NMFS (2015a). "80 FR 34371 IHA Shell Ice Overflight Surveys in the Beaufort and Chukchi Seas, Alaska." Federal Register **80**: 34371-34384.

NMFS (2015b). "80 FR 35744 IHA Shell Exploration Drilling Program in the Chukchi Sea, Alaska." Federal Register **80**: 35744-35780.

NMFS (2015c). "80 FR 39062 IHA Hilcorp Shallow Geohazard Survey in the Beaufort Sea, Alaska." Federal Register **80**: 39062-39076.

NMFS (2015d). "80 FR 40016 IHA SAExploration Marine Seismic Survey in the Beaufort Sea, Alaska." Federal Register **80**: 40016-40037.

NMFS (2015e). Biological Opinion: BOEM and BSEE Lease Sale 193 Oil and Gas Exploration Activities in Chukchi Sea, Alaska, National Marine Fisheries Service**:** 460 pp.

NMFS (2015f). Biological Opinion: IHA SAExploration, Inc. 2015 3D Seismic in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 169 pp.

NMFS (2015g). Biological Opinion: IHA Shell Aviation Operations Associated with Ice Condition Monitoring May 2015 - April 2016 Over the Beaufort and Chukchi Seas, Alaska, National Marine Fisheries Service**:** 25 pp.

NMFS (2015h). Biological Opinion: Proposed IHA Hilcorp Shallow Geohazard and Strudel Scour Surveys in Foggy Island Bay, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 63 pp.

NMFS (2015i). Final Environmental Assessment for IHA to Conduct Open-water Seismic and Geohazard Surveys in the U.S. Beaufort Sea. Silver Spring, MD, National Marine Fisheries Service**:** 74 pp.

NMFS (2016a). "81 FR 31594 Notice of Proposed IHA Shell Anchor Retrieval Chukchi and Beaufort seas, Alaska." Federal Register **81**: 31594-31612.

NMFS (2016b). "81 FR 40274 IHA Quintillion Subsea Cable Laying Chukchi and Beaufort seas, Alaska." Federal Register **81**: 40274-40282.

NMFS (2016c). "81 FR 47240 Final Rule: 2016 Apache Cook Inlet Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to Seismic Surveys in Cook Inlet, Alaska." Federal Register **81**: 47240-47280.

NMFS (2016d). "81 FR 52614 IHA for Naval Shipyard Construction Activities Kittery, Maine." Federal Register **81**: 52614-52635.

NMFS (2016e). Biological Opinion: IHA 2016 Fairweather Anchor Retrieval Activities in Chukchi and Beaufort Seas, Alaska, National Marine Fisheries Service**:** 175 pp.

NMFS (2016f). Effects of Oil and Gas Activities in the Arctic Ocean, Final Environmental Impact Statement. Anchorage, AK, National Marine Fisheries Service**:** 1276 pp + appendices.

NMFS (2016g). Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. NOAA Technical Memorandum. Silver Spring, MD, National Marine Fisheries Service**:** 178 pp.

NMFS (2017a). "82 FR 38877 IHA Quintillion Subsea Cable Operations and Maintenance Activities in the Arctic Ocean." Federal Register **82**(157): 38877-38895.

NMFS (2017b). Biological Opinion: BOEM and BSEE 2017-2022 Oil and Gas Lease Sale 244 in Cook Inlet, Alaska, National Marine Fisheries Service**:** 307 pp.

NMFS (2018a). "83 FR 19224 IHA Harvest Cook Inlet Pipeline Cross Inlet Extension Project." Federal Register **83**: 19224-19236.

NMFS (2018b). Biological Opinion: Issuance of U.S. Army Corps of Engineers Permit and IHA for Harvest Cook Inlet Pipeline Cross-Inlet Extension Project, National Marine Fisheries Service**:** 106 pp.

NMFS (2018c). Biological Opinion: Liberty Oil and Gas Development and Production Plan Activities, Beaufort Sea, Alaska. Juneau, AK, National Marine Fisheries Service**:** 243 pp.

NMFS (2018d). Biological Opinion: Proposed IHA Office of Naval Research (ONR) Arctic Research Activities 2018-2021 in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 115 pp.

NMFS (2018e). Letter of Concurrence: Hilcorp 2018-2028 Simpson Lagoon Dredging and Screeding in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 20 pp.

NMFS (2018f). Revision To: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. NOAA Technical Memorandum, U.S. Department of Commerce National Oceanic and Atmospheric Administration, National Marine Fisheries Service**:** 167 pp.

NMFS (2019a). "84 FR 37442 Final Rule and LOA 2019-2024 Hilcorp Oil and Gas Activities in Cook Inlet, Alaska." Federal Register **84**: 37442-37507.

NMFS (2019b). "84 FR 37442 Final rule: Issuance of Letters of Authorization (LOA): Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Oil and Gas Activities in Cook Inlet, Alaska." Federal Register **84**(147): 37442-37506.

NMFS (2019c). "84 FR 70274 Final Rule Hilcorp Construction and Operation of the Liberty Drilling and Production Island, Beaufort Sea, Alaska." Federal Register **84**: 70274-70325.

NMFS (2019d). Biological Opinion: BLM Oil and Gas Lease Sale Arctic National Wildlife Refuge Coastal Plain Beaufort Sea Coast, Alaska, National Marine Fisheries Service**:** 141 pp.

NMFS (2019e). Biological Opinion: BOEM, BSEE, EPA, and USACE Authorizations for Hilcorp Liberty Oil and Gas Development and Production Activities in Beaufort Sea, Alaska, National Marine Fisheries Service**:** 236 pp.

NMFS (2019f). Biological Opinion: Final Rule, Hilcorp Alaska and Harvest Alaska Oil and Gas Activities, Cook Inlet Alaska, National Marine Fisheries Service**:** 261 pp.

NMFS (2019g). Letter of Concurrence: Oil Search Alaska (OSA) Nanushuk Oliktok Dock Screeding and Module Offloading, Oliktok Point, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 43 pp.

NMFS (2020a). "85 FR 43382 Notice of Proposed IHA AGDC Alaska LNG Construction in Prudhoe Bay, Alaska." Federal Register **85**: 43382-43412.

NMFS (2020b). "85 FR 50720 LOA 2021-2025 AGDC Alaska LNG Construction Cook Inlet, Alaska." Federal Register **85**: 50720-50756.

NMFS (2020c). "85 FR 83451 Final Rule: Hilcorp-Eni Ice Road, Trail and Pad Construction, Operation, Maintenance, Alaska North Slope." Federal Register **85**: 83451-83473.

NMFS (2020d). Biological Opinion: Proposed Rule and LOAs to Hilcorp Alaska, LLC and Eni U.S. Operating Co. Inc. for 2020 to 2025 Ice Road and Trail Activities on the North Slope, Beaufort Sea, Alaska, National Marine Fisheries Service**:** 99 pp.

NMFS (2020e). "LOA Hilcorp Liberty Production and Development Island Beaufort Sea, Alaska 2021-2026." 10 pp.

NMFS (2021). Vessel Strike Avoidance Measures, National Marine Fisheries Service**:** 3 pp.

NOAA (2015). NOAA Administrative Order (NAO) 216-104A: Management and Utilization of Aircraft**:** 8 pp.

Norman, R. G. and C. R. J. Greene (2000). "An autonomous acoustic recorder using a directional sensor for locating calling bowhead whales." The Journal of the Acoustical Society of America **108**(5): 2582-2582.

Nowacek, D. P., C. W. Clark, D. Mann, P. J. Miller, H. C. Rosenbaum, J. S. Golden 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.

NPC (2015). Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources, National Petroleum Council**:** 1000 pp.

NRC (2003a). Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington, DC, National Research Council, National Academic Press**:** 460 pp.

NRC (2003b). Ocean Noise and Marine Mammals. Washington, DC, National Research Council.

PAME and A. Council (2019). Underwater Noise in the Arctic: A State of Knowledge Report, Protection of the Arctic Environment and the Arctic Council**:** 60 pp.

Pangerc, T., S. Robinson, P. Theobald and L. Galley (2016). Underwater sound measurement data during diamond wire cutting: First description of radiated noise.

Patterson, H., S. B. Blackwell, B. Haley, A. Hunter, M. Jankowski, R. Rodrigues, D. Ireland and D. W. Funk (2007). Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–September 2006: 90-day report, Shell Offshore, Inc.**:** 150 pp.

Rankin, C. H., T. Abrams, R. J. Barry, S. Bhatnagar, D. F. Clayton, J. Colombo, G. Coppola, M. A. Geyer, D. L. Glanzman, S. Marsland, F. K. McSweeney, D. A. Wilson, C. F. Wu and R. F. Thompson (2009). "Habituation revisited: an updated and revised description of the behavioral characteristics of habituation." Neurobiology Learning Memo **92**(2): 135-138.

Reichmuth, C., J. M. Sills, A. Brewer, L. Triggs, R. Ferguson, E. Ashe and R. Williams (2020). "Behavioral assessment of in-air hearing range for the Pacific walrus (*Odobenus rosmarus divergens*)." Polar Biology **43**(6): 767-772.

Rhodes, R. and N. Spiegel (2017). A Literature Review of the Effects of Unmanned Aircraft systems on Seabirds and Marine Mammals, National Oceanic and Atmospheric Administration**:** 22 pp.

Richardson, W. J. (2006). Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2005: Annual Summary Report., BP Exploration (Alaska) Inc.**:** 86 pp.

Richardson, W. J. (2007). Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2006: Annual Summary Report**:** 84 pp.

Richardson, W. J. (2008). Monitoring of industrial sounds, seals and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999 - 2004, BP Exploration (Alaska) Inc.**:** 467 pp.

Richardson, W. J. (2011). Monitoring of industrial sounds, seals, and bowhead whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea: Comprehensive Report for 2005-2010., LGL Alaska Research Assoc. Inc., Greeneridge Sciences Inc., WEST Inc. and Applied Sociocultural Research**:** 266 pp.

Richardson, W. J., C. R. Greene Jr., C. I. Malme and D. H. Thomson (1995). Marine Mammals and Noise. San Diego, Academic Press.

Richardson, W. J. and M. T. Williams (2001). Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2000. [Draft], BP Exploration (Alaska) Inc.**:** 316 pp.

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, 2001., BP Exploration (Alaska) Inc.**:** 337 pp.

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., BP Exploration (Alaska) Inc.**:** 343 pp.

Richardson, W. J. and M. T. Williams (2004). Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999–2003. [Annual and Comprehensive Report, December 2004.], BP Exploration (Alaska) Inc.**:** 297 pp.

Richardson, W. J. and M. T. Williams (2005). Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2004: Summary Report; Appendix H in Richardson 2008, BP Exploration (Alaska) Inc.**:** 77 pp.

Robertson, T. and L. K. Campbell (2020a). Oil Spill Occurrence Rates for Cook Inlet, Alaska Oil and Gas Exploration, Development, and Production. Plymouth, MA, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 78 pp.

Robertson, T. and L. K. Campbell (2020b). Oil Spill Occurrence Rates from Alaska North Slope Oil and Gas Exploration, Development, and Production. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management**:** 72 pp.

Robertson, T. L., L. K. Campbell, L. Pearson and B. Higman (2013). Oil spill occurrence rates for Alaska North Slope crude and refined oil spills. Report to Bureau of Ocean and Energy Management. Seldovia, AK, Nuka Research & Planning Group LLC**:** 155 pp.

SAExploration (2012). Apache Cook Inlet 3D Seismic Protected Species Monitoring Program**:** 20 pp.

Schoeman, R. P., C. Patterson-Abrolat and S. Plön (2020). "A Global Review of Vessel Collisions With Marine Animals." Frontiers in Marine Science **7**: 292 pp.

Shell (2011). Environmental Impact Analysis, Revised Chukchi Sea Exploration Plan OCS Lease Sale 193, Chukchi Sea, Alaska: Burger Prospect: Posey Blocks 6714, 6762, 6764, 6812, 6912, and 6915. Anchorage, AK, U.S. Dept. of the Interior, Bureau of Ocean Energy Management Regulation and Enforcement**:** 555 pp.

Shell Gulf of Mexico Inc. (2011a). 2011 Marine Mammal Monitoring and Mitigation Plan for Exploration Drilling of Selected Lease Areas in the Alaskan Chukchi Sea, Shell Gulf of Mexico Inc.**:** 30 pp.

Shell Gulf of Mexico Inc. (2011b). Plan of Cooperation Addendum Revised Chukchi Sea Exploration Plan OCS Lease Sale 193 Chukchi Sea, Alaska. Anchorage, AK**:** 178 pp.

Shell Offshore Inc. (2011). Plan of Cooperation Addendum Revised Outer Continental Shelf Lease Exploration Plan Camden Bay Beaufort Sea, Alaska. Anchorage, AK**:** 216 pp.

Sitkiewicz, S., W. Hetrick, K. Leonard and S. Wisdom (2018). 2018 Harvest Alaska Cook Inlet Pipeline Project Monitoring Program Marine Mammal Monitoring and Mitigation Report, Harvest Alaska LLC**:** 98 pp.

SLR (2017). Hilcorp Liberty Project Underwater and Airborne Noise Modeling. Vancouver, BC, Hilcorp Alaska, LLC**:** 40 pp.

Sorstrom, S. E., P. J. Brandvik, I. Buist, P. Daling, D. Dickins, L. Faksness, S. Potter, J. F. Rasmussen and I. Singsaas (2010). Report No. 32: Joint Industry Prorgam on Oil Spill Contingency for Arctic and Ice-Covered Waters Summary Report. Oil in Ice - JIP; SINTEF JIP; SINTEF Materials and Chemistry Marine Environment Technology**:** 40 pp.

Sousa-Lima, R. S., D. P. Fernandes, T. F. Norris and J. N. Oswald (2013). A review and inventory of fixed autonomous recorders for passive acoustic monitoring of marine mammals: 2013 state-of-the-industry. 2013 IEEE/OES Acoustics in Underwater Geosciences Symposium**:** 9 pp.

Southall, B., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. G. 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): 411-509.

Southall, B. L., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. P. Nowacek and P. L. Tyack (2019a). "Errata: Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects." Aquatic Mammals **45**(5): 569-572.

Southall, B. L., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. P. Nowacek and P. L. Tyack (2019b). "Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects." Aquatic Mammals **45**(2): 125-232.

Stephen R. Braund & Associates (2009). Impacts and benefits of oil and gas development to Barrow, Nuiqsut, Wainwright, and Atqasuk harvesters. Utqiagvik, AK, North Slope Borough**:** 377 pp.

Thewissen, J. G. M. and C. George (2021). The Bowhead Whale *Balaena mysticetus*: Biology and Human Interactions. J. C. George and J. G. M. Thewissen, Academic Press, Elsevier**:** 640 pp.

United States Court of Appeals (2018). Ringed Seal ESA Listing Opinion**:** 5 pp.

USACE (1999). Final Environmental Impact Statement Northstar Beaufort Sea Oil and Gas Development Project and Record of Decision. Anchorage AK, U.S. Army Corps of Engineers. **Vol. 1-5:** 1000+ pp.

USACE (2012). Point Thomson Project Final Environmental Impact Statement. Anchorage, AK, U.S. Army Corps of Engineers. **Vol. 1-2:** 564 pp + appendices.

USACE (2018). "Public Notice of Application for Permit POA-2017-509 Cook Inlet Cross Inlet Extension Project."

USFWS (2003). Biological Opinion: Steller's Eiders from Fairweather Geophysical/Veritas DGC 3D Seismic in Lower Cook Inlet, Alaska, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 51 pp.

USFWS (2004). "69 FR 12174 LOAs Industry Oil and Gas Operations Beaufort Sea, Alaska." Federal Register **69**: 12174.

USFWS (2006). "71 FR 26770 Notice of Receipt of IHA Applications Shell ConocoPhillips and GXT Houston Open-water Seismic Chukchi Sea, Alaska." Federal Register **71**: 26770-26781.

USFWS (2012). Biological Opinion: LOAs Shell 2012 Exploration Activities in Chukchi Sea, Alaska. Fairbanks, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 14 pp.

USFWS (2013). "78 FR 11766 Final Rule Endangered and Threatened Wildlife and Plants; Special Rule for the Polar Bear Under Section 4(d) of the Endangered Species Act." Federal Register **78**: 11766-11794.

USFWS (2014a). "79 FR 51584 Notice of Receipt of IHA Application Apache, SAExploration, Bluecrest Exploration Cook Inlet, Alaska." Federal Register **79**: 51584-51600.

USFWS (2014b). Final Stock Assessment Report Northern Sea Otter (*Enhydra lutris kenyoni*) Southcentral Alaska Stock, US Fish and Wildlife Service**:** 19 pp.

USFWS (2014c). Final Stock Assessment Report Northern Sea Otter (*Enhydra lutris kenyoni)* Southwest Alaska Stock, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 23 pp.

USFWS (2014d). "IHA BlueCrest Exploration & Drilling Program Cook Inlet, Alaska." 9 pp.

USFWS (2014e). "IHA SAExploration 3D Seismic Lower Cook Inlet, Alaska." 8 pp.

USFWS (2015a). Biological Opinion: BOEM and BSEE Oil and Gas Activities Associated with Lease Sale 193. Fairbanks, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 189 pp.

USFWS (2015b). Letter of Concurrence: Northern Sea Otters for Shell Offshore Support Vessels Dutch Harbor to Chukchi Sea, Alaska. Fairbanks, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 4 pp.

USFWS (2016a). "81 FR 52276 Final Rule Industry O&G Activities Beaufort Sea, Alaska." Federal Register **81**(151): 52276-52320.

USFWS (2016b). Biological Opinion: 2016-2021 Polar Bear and Pacific Walrus Incidental Take Regulations Beaufort Sea, Alaska. Fairbanks, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 76 pp.

USFWS (2016c). Environmental Assessment For a Final Rule to Authorize the Incidental Take of Small Numbers of Polar Bear and Pacific Walrus During Oil and Gas Activities in The Beaufort Sea and Adjacent Coastal Alaska. Anchorage, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 128 pp.

USFWS (2016d). Final EA for an IHA for Pacific Walruses (*Odobenus rosmarus divergens*) in Alaska and Associated State and Federal Waters during Installation of the Quintillion Fiber Optic Cable, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 64 pp.

USFWS (2017a). Biological Opinion: Proposed Oil and Gas Lease Sale 244 in Cook Inlet, Alaska. Anchorage, AK, U.S. Dept. of the Interior, U.S. Fish and Wildlife Service**:** 168 pp.

USFWS (2017b). "IHA Quintillion Subsea Cable Installation Bering, Chukchi and Southern Beaufort Sea, Alaska." 8 pp.

Williams, M. T., C. S. Nations, T. G. Smith, V. D. Moulton and C. 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.

Willoughby, A. L., M. C. Ferguson, R. Stimmelmayr, 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**: 1667-1679.

Wright, S. K., S. M. Wilkin, A. S. Jensen, T. K. Rowles, J. Dushane and M. Ziccardi (2017). Arctic marine mammal disaster response guidelines: National Marine Fisheries Service Guidance Report. NOAA Technical Memorandum. Juneau, Alaska, National Marine Fisheries Service**:** 84 pp.

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